



ECONOMIC ZOOARCHAEOLOGY

Studies in Hunting, Herding and Early Agriculture

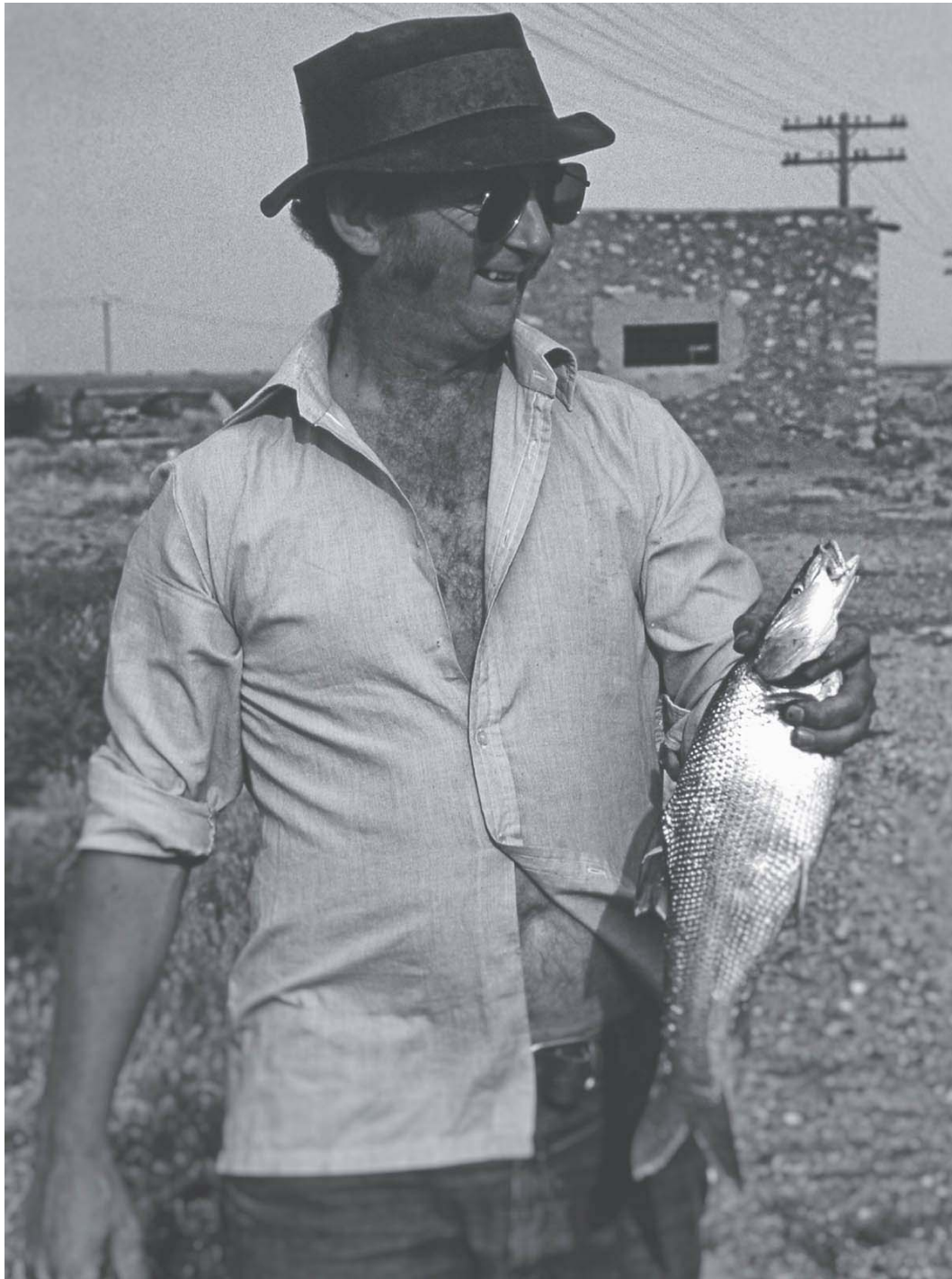
EDITED BY
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Frontispiece: Tony Legge caught this fish in the Euphrates, near Raqqah, in 1983. He was particularly pleased with himself because several local 'experts' had advised him that he would catch nothing in this spot. Tony's eye for water did not let him down, however: he hooked the fish on his first cast. Photo by Peter Rowley-Conwy.

ECONOMIC ZOOARCHAEOLOGY

STUDIES IN HUNTING, HERDING AND EARLY AGRICULTURE

Edited by

PETER ROWLEY-CONWY, DALE SERJEANTSON AND
PAUL HALSTEAD

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Front cover: The “Cairo” deer, see Ch. 33, Ikram and Bertini; Metapodials (photo by Terry O’Connor).

Back cover: Tony Legge teaching bone identification in the field, at Danilo in Croatia in 2005 (photo by A.M.T. Moore).

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Introduction

Peter Rowley-Conwy, Dale Serjeantson and Paul Halstead

Economic archaeology is the study of how past peoples exploited animals and plants, using as evidence the remains of those animals and plants. The animal side is usually termed zooarchaeology, the plant side archaeobotany. What distinguishes them from other studies of ancient animals and plants is that their ultimate aim is to find out about human behaviour – the animal and plant remains are a means to this end. The papers in this volume are put together in memory of Tony Legge, who died on 4th February 2013. Tony was an active ‘bone man’, who throughout his career studied animal bones from archaeological sites. As a zooarchaeologist, he was a passionate believer that because the bones are on archaeological sites as a result of human activities, they tell us a great deal about what *people* did; that animal bones are as fundamentally archaeological a source of information as potsherds and stone tools. Zooarchaeology, therefore – not archaeozoology, still less palaeontology (Legge 1978).

True to his archaeological focus, Tony’s interests ranged widely across the discipline, well beyond the confines of animal bones. The editors of this volume were all students of Tony during the 1970s and 1980s, DS in the (then) Department of Extra-Mural Studies in the University of London, PH and PR-C in the ‘Bone Room’ in the (then) Department of Archaeology in the University of Cambridge. The brief we gave to potential contributors to this volume was simply that their papers should be about something that would have interested Tony. The contributions come from as far afield as Canada and Argentina, to Russia, Egypt and South Africa. The breadth of topics that the papers cover is the best possible testimony to Tony’s range of interests.

If Tony is to be identified with one particular area of research, it is probably the human use of dairy products. Pioneering work on the ageing and sexing of cattle bones was carried out by Charles Higham (whose paper on a different aspect of Tony’s work forms Chapter 4 of this volume), another member of the Cambridge ‘Bone Room’ (e.g., Higham 1967). Tony developed this in his work on British Neolithic and Bronze Age cattle remains. He argued that a major cull of very young calves, coupled with a predominance of females among the sub-adults and adults, revealed that most males were killed as calves so that the milk was available for human consumption. He first put this argument forward at a conference organised by Alison Sheridan in New Hall, Cambridge, in January 1979. His first publications on the subject appeared two years later (Legge 1981a; 1981b), in two volumes both edited by Roger Mercer (whose paper on the British Neolithic forms Chapter 24 of this volume). The first was on Grimes Graves, where the many juvenile jaws and the mainly female adults formed the basis of Tony’s classic argument for dairying. The second paper included discussion of southern British Neolithic causewayed enclosures, which had too few jaws to produce an age profile, but did have a

preponderance of females among the sub-adults and adults. Tony argued that these females were the *surplus* animals from Neolithic milking economies, reared at domestic settlements elsewhere. The argument for dairying immediately caused controversy, as the published discussion following Legge (1981b) shows. Furthermore, 1981 also saw the publication of the first of Andrew Sherratt's major papers on the 'Secondary Products Revolution' (Sherratt 1981; 1983), which argued that milking was likely to have started long after the initial domestication of cattle, although it is now recognised that his dating is too late. The debate over how early dairying is visible in the archaeological record has continued ever since, and various papers in this volume (Chapters 14–19 'The zooarchaeology of milking controversy') address the issue. Other lines of evidence have subsequently been deployed. Lipids in ceramics have been used to argue for dairying in the earliest Neolithic of Britain (Cramp *et al.* 2014), and much earlier than that in the eastern Mediterranean (Evershed *et al.* 2008). Isotopic studies of cattle teeth suggest that weaning at an early age, suggestive of human exploitation of the milk, was also taking place very early (Balasse and Tresset 2002). These methods are discussed in the present volume by Alan Outram in Chapter 18, and Rosalind Gillis in Chapter 16, respectively.

Tony made several major contributions (in addition to that on the antiquity of dairying) to our understanding of the prehistory of Britain, some reactions to which follow below (Chapters 23–28 'Prehistoric Britain'). He also worked well beyond his native shores. His bone work ranged from Spain to Syria to Turkmenistan and, appropriately, Chapters 29–33 of this volume are devoted to studies of animal exploitation in 'Continental Europe and the Mediterranean'. In 1977 he spent some time in Australia, where he was able to combine his commitment to zooarchaeology with his love of hunting (in Chapter 5, Jim O'Connell describes the acquisition of some feral pig skeletons, and we publish Tony's own paper on them in Chapter 7). These twin passions are also addressed in Chapters 20–22 ('Farmers that hunt').

Tony loved many aspects of 'abroad': he was as fond of the wines of Spain and the Mediterranean as he was of the beer of his native Cambridgeshire, he enjoyed meeting local farmers, herders and hunters, and he delighted in conducting ethnographic interviews about animal management practices (Fig. 1). His interest in the hunting and herding of Near Eastern animals was, however, not always paralleled by his enthusiasm for eating them; his reaction when a very senior sheikh (reputed to be a relative of a major Near Eastern royal family) forcefully offered him the eyeball of a fat-tailed sheep wrapped in a lump of semi-congealed fat from the eponymous tail nearly caused a diplomatic incident. He took a dim view of drivers and airline mechanics, and harboured a deep-seated dread of petty officials in uniform that contrasted incongruously with his large frame and (once safely back on the insular side of the English Channel) truculent manner.

Tony's approach to solving problems was utterly practical. Whether he was constructing a contraption for hanging up pheasants or keeping the rain out of his tent, defleshing a 30-stone pig (see Robin Dennell's Chapter 1), cold-forging a spare part for his aged van at Nahal Oren, or devising a method for determining the seasonality of Epipalaeolithic gazelle bones, his concern was always 'how to do it'. Tony's technological savvy led him to become one of the pioneers in methods of data recovery during excavation. This included designing practical sieve frames and proselytising their use – in Chapter 13, Dale Serjeantson describes his instructions to an excavator seeking advice on how to dig a complex site: 'sieve everything'. He was also instrumental in devising a practical froth flotation machine for recovering plant remains – in Chapter 4, Charles Higham describes how a conversation with Tony impacted on the study of early rice cultivation in Southeast Asia. Chapters 7–13 ('Zooarchaeological method and theory') include two new biometric contributions by Tony on feral pigs (Chapter 7) and Barbary sheep (Chapter 8), completed posthumously by PR-C and Chris Stimpson, respectively.



Fig. 1. Tony Legge, wearing what he called his 'rat-catcher's hat', talking to Bedouin in the Syrian steppe somewhere near Resafa in 1983, during the extended expedition by the 'Abu Hureyra crew'. Next to Tony, in leather jacket, is Afif Dakermanji, the translator, from The International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo. On the right are (nearest the camera) Gordon Hillman, then Sue Colledge, finally David Harris. Photo PR-C.

As Chris Stimpson notes at the start of Chapter 8, 'but where's the data?' was a question Tony commonly asked. He had no time for fashionable but empirically ungrounded speculations about the past, which he was wont to dismiss in the most colourful and unambiguous terms. Mysteries intrigued him, however, and in this volume we present two, one solved and one not. Sonia and Terry O'Connor (Chapter 28) demonstrate that a claimed Mesolithic harpoon from Devon is in fact part of a modern rattle for luring corncrakes, an explanation on the face of it so unlikely that Tony would have loved it. Salima Ikram and Louise Bertini (Chapter 33) report on a fresh deer skeleton that the local Bedouin claim to have found in the Eastern Desert of Egypt – biogeographically highly improbable, as the authors note. Cairo Zoo has not lost any deer, so profit-motivated deer rustling by the Bedouin can probably be ruled out. We look forward to the full explanation in due course.

Tony was highly articulate, a gift which made him an inspirational and insightful teacher (in Chapter 2 Harvey Sheldon describes his work at London University's Department of Extra-Mural Studies). He had no time for pomposity, which he punctured with devastating one-liners and a richly onomatopoeic vocabulary that owed more to the Anglo-Saxon than the Norman-French roots of the English language. Tony was a man of strong convictions: as his brother Keith aptly put it, he only saw black and white, where others also see grey. On the other hand, in addition to his remarkable talent for deflating the pompous, he was also unusually willing to laugh at himself and indeed told some of the best stories about his mishaps abroad, such as his landing head-first in the wedding cake at a firewater-

fuelled feast in Turkmenistan.

During his time in academia (described at different stages and from various perspectives in Chapters 1–6 ‘Bone man: the career and influence of Tony Legge’), Tony inspired many people, as the range of contributions to this volume shows. He always had time to discuss animal bones and offer help and advice. It made no difference whether the discussion was in the lab or in the pub, or whether he was talking to a senior professor, or the lowliest undergraduate or evening class student: he had time for all, and talked with palpable enthusiasm. He in turn owed his career to others. He first encountered archaeology in 1962, in the person of John Alexander, who was doing extra-mural lecturing in Cambridge, and this made him decide to apply for entry to the University of Cambridge as a mature undergraduate. He used to describe the way the university admitted him: he applied to Churchill College in 1966, where he was interviewed by Dr Richard Hey of the university’s Sub-Department of Quaternary Research. After a brief conversation, Hey said ‘right, you’re in.’ It is worth reflecting that the days when snap decisions could be made based on personal judgment are long gone; and so are the days when a mature applicant with few resources could even contemplate doing a degree. We are the poorer for their passing.

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Part I

Bone Man: the career and influence of Tony Legge

Tony Legge (1939–2013)

Robin Dennell

Tony Legge was an unrepeatable one-off. In the course of my career, I've been very fortunate in knowing and working with some remarkable people, and without doubt, Tony was one of them. In the Cambridge Archaeological pantheon of larger than life characters, he could easily hold his own with the best of them. He and I were contemporaries as undergraduates at Cambridge and then as post-graduates working in the Bone Room under Eric Higgs, further ago than I care to remember, between 1966 and 1973. Tony came to Cambridge as a mature student and already under the spell of Eric Higgs; I arrived as a grammar school oik, far less street-wise and with far less self-confidence. From the beginning, Tony's pronouncements on the follies and foibles of the great and the good did much to make Cambridge far less awesome for me than I first thought it was.

First, Tony and his career. He arrived knowing what he wanted to do – the history of farming and animal exploitation – and who he wanted to work with. In the late 1960s, he spent the summers with Eric Higgs at Asprochaliko and Kastritsa in Greece. After graduation in 1969 we both joined the British Academy Research Project into the Early History of Agriculture under Eric Higgs and Tony switched to Israel, working at the Natufian sites of Nahal Oren and Rakafet. In 1972 he worked on a Neolithic site in Cyprus and after that, with Ruth Tringham for several seasons in the 1970s at the Neolithic site of Selevac in what is now Serbia. In the early 1980s, he worked with Andrew Moore and Gordon Hillman at the critically important early Neolithic site of Abu Hureyra in Syria, but he also worked in Spain with Richard Harrison at Moncín, and on the material from Star Carr with Pete Rowley-Conwy. The early 1990s saw him working on David Harris's wonderful project at the major Neolithic tell site of Djeitun in Turkmenistan. Subsequently in the early years of this century, he worked in Croatia at three neolithic sites, Danilo, again with Andrew Moore, Pokrovnik, and Cista Mala Velistak. Most recently, he was working at Almeira in Spain with his partner Liz on a large collection of Barbary sheep (Legge and Stimpson, this volume), and was also involved in Graeme Barker's Libyan project in the faunal analysis of the superb Palaeolithic to Neolithic sequence at the Haua Fteah. In a way here, he came full circle, as the original analysis of the fauna was by Eric Higgs, under whom he had first started 40 years previously. In between all these overseas expeditions, he worked at various British sites, including Hambledon Hill, the flint mines at Grime's Graves, Norfolk and Down Farm, Dorset (Bradley, this volume). So, looking back, he packed in a remarkably full and productive career in at least eight countries, plus various other trips to Australia and Portugal travelling

and working, right into his 70s, and right up to the end. Overall, he had unrivalled first-hand experience of early farming sites from Spain to Central Asia, and from Britain to Israel.

As I mentioned earlier, we were contemporaries, back in the pre-decimal days when £10 a week was good money, beer was 1 shilling and sixpence a pint and you could get 3 gallons of petrol for a pound. Times then were good: the New Archaeology really was new, the Bone Room in the Faculty of Archaeology and Anthropology was making waves, and Cambridge was definitely the place to be as an archaeology student. I got to know Tony better in our second undergraduate year when I also fell under the spell of Eric Higgs. Tony taught me my basic knowledge of faunal identification: I learnt this the best way possible, by defleshing carcasses with him at the Experimental Research Farm at Babraham, near Cambridge. I remember dismembering several delightful Soay sheep, but the one I most remember was a 30-stone pig which we strung up on a gantry. Tony then told me to sit under it and hold it by its ears whilst he sawed off the head. He didn't tell me that it hadn't been bled beforehand. He found it far funnier than I did when he cut the main artery. In 1968 we were both at Charles McBurney's excavation at La Cotte de la St Brelade in Jersey, which was probably the coldest and most miserable excavation I have ever worked on. On one occasion, Tony and I with Derek Sturdy and John Harris were deputised to carry an enormously heavy mammoth bone, which was encased in plaster, placed in a wooden crate and mounted on scaffolding poles, across the bay. We quickly realised that McBurney's many undoubted gifts did not include the ability to read a tide table. As Tony and the others were 6 ft tall or more, they coped reasonably well, but were more or less reduced to dragging me out of the sea as it rose ever higher. We had a better time the following year when on the afternoon after our last finals exam, there was a disgracefully intoxicated time in a punt, during which I lost my glasses and I think we both fell into the Cam. Later that summer, we worked together at Nahal Oren, which was the only Higgs excavation I ever worked on. Tony was there with his kids; Karen was 7, and Alexander was 5. They entertained themselves playing with the snakes, spiders and scorpions while Tony ran the excavation and I was in charge of the sieves and what was one of the first seed machines, or large-scale flotation devices, that Tony had helped design. Once a week, Eric would glide by in his Land Rover and offer us a cigar each. Tony and I also worked together at Grimes Graves for a while in the early 1970s, which finally killed off any enthusiasm I had for the British Neolithic. I also recall another delightful if sozzled afternoon in a punt with Tony, Ruth Tringham and Anita Furshpan in 1973 in what was my last summer in Cambridge. After that, I moved to Sheffield, and Tony later was employed in London, and our careers went in different directions – mine to Iran, then Pakistan and more recently, China – so we usually met up at conferences and workshops, most recently a few months before he died.

I valued a lot in Tony – he was jovial (most of the time), irrepressible, seemingly indestructible and permanent; always open with his opinions, and utterly unconcerned if they were not politically correct. He was a great story-teller, and had a devastating repertoire in one-liners. I remember his dismissal of someone's ability to do fieldwork: "If there was a cow pat in the Sahara, he'd step in it". And of phenomenology, and any phenomenological approach: "what's the point of using a model that you can't even spell?" Tony's mind was not subtle but it was razor sharp. He knew what would and would not work, what questions were worth asking (and which were not), and he also knew what his faunal data could and could not show. Unlike some people I've met, he never pushed his identifications or inferences beyond their limits – interpretations of data may change, but in 50 years' time, his identifications will most likely still be reliable. And he always had an unfailing ability to sort out the wheat from the chaff. For me, what Tony has bequeathed is what I would call the Leggometer. I envisage this as a hand-held device you can take to any conference, departmental or faculty meeting. Tony's contribution there is quite simple – the more fatuous, pointless, stupid, and impractical the

proposal, the louder the raspberry.

Tony was larger than life, huge fun, great company and an inspiration to many (and perhaps a source of terror for a few) – so in this volume we will remember and celebrate a remarkable and much missed friend and colleague.

Tony Legge and continuing education in archaeology at the University of London 1974–2004

Harvey Sheldon

With a contribution by Nick Bateson, Mike Hacker and Geraldine Missig

Tony Legge spent much of his archaeological career in London, closely involved with the provision of higher-level educational courses in archaeology for adult students. He arrived here in 1974, succeeding John Alexander as the new Staff Tutor in Archaeology in London University's Department of Extra-Mural Studies and retired 30 years later as Professor of Environmental Archaeology at Birkbeck, the College of London University into which the Extra-Mural Department had been merged in 1989. To those of us who worked with him, Tony was a great colleague, loyal, encouraging, supportive, innovative and questioning, even iconoclastic, especially when received academic wisdom came within target range, but always trying to get archaeology a higher profile. He was also a good friend whose advice I valued immensely.

A profile of Tony written soon after his arrival in London (Anon 1974) shows that by then he was well known for his interests and expertise in early agriculture and the domestication of plants and animals (Fig. 2.1). He had carried out fieldwork in Europe and the Middle East as well as in Britain and developed a seed machine used to recover samples through flotation. As much environmental information comes from archaeological investigations it is hardly surprising that the immensely practical Tony was concerned with developing better methods of recovery throughout his career.

Early career

Between leaving school in 1957 and 1966, but with an interval for National Service, Tony worked at the Institute of Animal Physiology at Babraham near Cambridge. His developing knowledge of farm animals in contemporary contexts seems to have gone hand in hand with a growing interest in studying fauna from earlier times and establishing its relationship to co-existent human communities.

Tony's first archaeological experience came from working on a Fenland Neolithic site in the year he joined Babraham. The excavation was directed by Graham Clark, whose earlier findings from the faunal remains at Star Carr, Tony was to revisit many years later. The staff included Eric Higgs, who would later lead the Cambridge-based Early History of Agriculture project. Digging with these two influential figures must have been a seminal experience for the 18-year-old novices.

Yet, as a young man living and working in the Cambridge area and becoming increasingly intrigued by archaeology, it was the influence of John Alexander, Cambridge University's Extra-Mural Archaeological Tutor between 1957 and 1965, which shaped Tony's archaeological progress. In a collective obituary for John, who died in 2010, to which we both contributed, Tony emphasised how, through participating in a series of John's classes and fieldwork projects, from 1962 onwards, his 'long standing but unsystematic interest' in archaeology was transformed. John also encouraged him to become a mature student at Cambridge where he completed his undergraduate degree in 1969.

Tony, during his student days, spent summers digging with Higgs abroad and after graduating worked on the Early History of Agriculture project. In the late 1960s and early 1970s he was based in the Bone Room at Cambridge and I first met him there, or in its immediate environs, early in 1971, while in Cambridge working on an excavation project for John Alexander. My memories of him there are largely coloured by our exploration, at his 'request', of nearby buildings that were actively in the process of being demolished. My role was to assist him, one step or less ahead of the demolition gang, to salvage useful materials, principally wood, that he wanted to turn into furniture. It was a task even more dangerous than the excavation project, which involved delving deep into the unstable interior of the town's medieval ditch.

New Extra-mural Lecturer

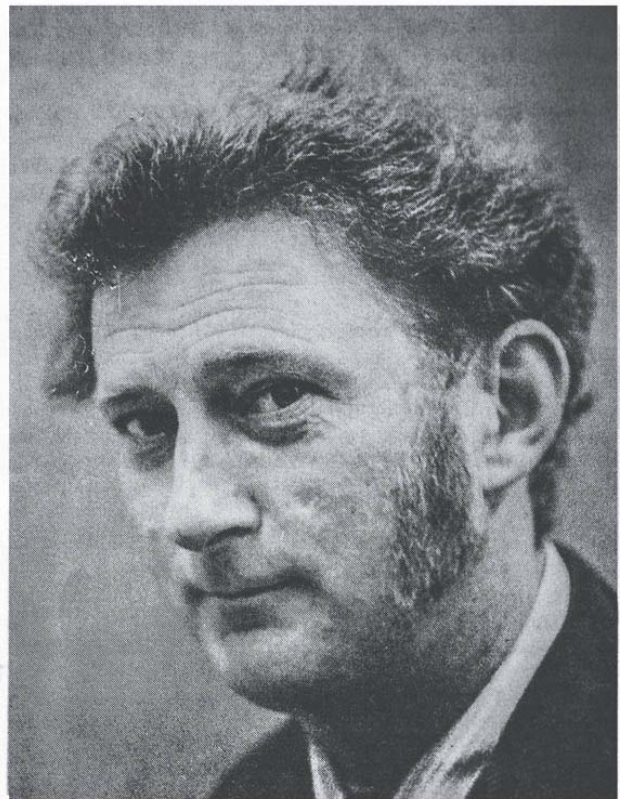
THE appointment of Anthony Legge as staff tutor in Archaeology at London University following the departure of John Alexander to Cambridge, may well lead to a change of emphasis in the range of extra-mural courses. His special interests are early agriculture and the domestication of plants and animals.

Now 35, Tony Legge left school at 16 and first studied archaeology in an adult education class. He went up as a mature student to Churchill College, Cambridge in 1966. On graduating he became a researcher working in the British Academy sponsored investigation into the Early History of Agriculture based at the Department of Archaeology in Cambridge.

He has become best known for his part in developing—with Cambridge colleagues—a "seed machine" designed to recover seeds from archaeological soils by froth flotation. His machines have been used in Britain, Palestine and Cyprus while the techniques have spread as far afield as Australia and have led to the discovery of the earliest known wheat and barley.

His fieldwork included co-direction with Eric Higgs of the Palestinian late Palaeolithic to Neolithic site of Nahel Oren between 1969-1972. He has also worked as environmental specialist on the American project at Tel Gezer and, nearer home, on recent D.O.E. excavations at Grimes Graves and Hambledon Hill.

As well as teaching Near Eastern and World Pre-historic archaeology Tony Legge hopes to provide training in the techniques of environmental archaeology as well as courses on various specialist aspects of the work.



Anthony Legge

(Photo: John Earp)

Fig. 2.1. Tony Legge in 1974 when he arrived at the Extra-Mural Department in London, as photographed for the London Archaeologist. Photograph: John Earp

John Alexander's influence on Tony's progress in archaeology was more than just a feature of his early academic development. To put Tony's London University career between 1974 and 2004 in

context, it is necessary to recall that as long ago as the mid-1950s John had set-up an archaeology programme for its Department of Extra-Mural Studies. Probably its most important constituent was the Diploma in Archaeology. Students undertaking it had to complete 4 years of rigorous part-time study, including each year a series of essays and an exam, as well as participate in field-work courses. The Diploma soon became very popular, especially with amateur archaeologists, often helping them to participate in rescue excavations that were carried out by London's local museums and excavation committees in the London area and beyond from the early 1960s onwards.

In 1965, John left his Cambridge post, returning to the London Department, this time as its first full time Staff Lecturer in Archaeology. He expanded the programme further, introducing in 1969 an equally rigorous three-year Field-Certificate in Archaeology, providing academic knowledge and field experience, intended especially for the growing body of amateur archaeological practitioners, who were often members of local societies assisting on rescue archaeological projects.

The Extra-Mural Department

Nearly a decade later, in 1974, John Alexander went back to Cambridge, this time to take up an internal University post. Tony won the hard-fought contest to succeed him in London, inheriting a large and thriving programme of archaeological courses. Perhaps the most obvious impact of Tony's tenure was the addition of Environmental Archaeology to the Diploma as a fourth-year option and the introduction into the overall programme of courses on animal bones, human skeletal remains and archaeobiology. Though the popularity of the original Diploma and Field Archaeology Certificate remained strong, to increase the archaeological coverage on offer to potential students, he developed new Diplomas, including ones specialising in Prehistoric Archaeology, Eastern Mediterranean Archaeology and Egyptology.

To Tony, teaching was paramount. I have often seen him at his most informal on-site, making use of a few fragments of bones in a finds tray, hold small groups of students gathered round him spellbound. In more formal classroom environs, Tony, with his depth of knowledge, vast practical experience, and awareness of both the possibilities and the limits of evidence, inspired his students. His sometimes iconoclastic viewpoint, often challenging of prevailing orthodoxies, however eminent their proponents, was balanced by a belief similar to that held by his predecessor John Alexander: that all students, once trained, could contribute to our knowledge of the past through their own studies.

With the help of Richard Temple, the Senate House Archivist, I investigated a number of Department of Extra-Mural Studies programme prospectuses from the 1970s and 1980s now housed there. I also consulted Birkbeck programme prospectuses for the early 2000s kindly made available by Geraldine Missig. The statistics suggest that in 1973–1974, the last year of John's tenure, the Department ran 101 courses, 27 of which were part of either the Diploma in Archaeology or the Certificate of Field Archaeology. The Department's programme of classes took place in a variety of educational institutions within Central and Greater London, including the City Lit, Morley College and the Mary Ward Centre. Some were also located beyond the Greater London boundaries at centres within the neighbouring counties of Essex, Hertfordshire, Kent and Surrey. Non-Diploma classes ranged from 'Anatolia' to 'Industrial Archaeology' and from 'Ancient Greece' to 'Romans and Saxons in Surrey'. Tony inaugurated a public lecture series held at the Institute of Archaeology on 'Research and Development in the Archaeology of the Americas'. The courses reflected the Department's inherited twin traditions of 'Extension' and 'Tutorial' classes, the former assessed through essays and exams, the latter more reliant on discussion and voluntary contributions from students. The scale of the programme was extensive and, as Tony later wrote, 'the sum of teaching hours probably exceeded all

other university departments in Britain when combined' (Legge 2011, 118).

The growth of the programme under John Alexander and the maintenance, as well the changes introduced by Tony, reflect the popularity of archaeology as a subject of study within University Extra-Mural Departments in Britain from the 1950s onwards. The Russell Committee, set up in 1969 to examine provision for adult education in Britain's Universities, reported that in 1969–1970, History and Archaeology courses, which were grouped together, were by far the largest category on offer, with more than 55,000 enrolments (Speight 2002, 80). Later research by Tony Brown revealed that the actual number of archaeological courses offered by the 33 Extra-Mural Departments rose from 195 in 1961–1962 to 687 in 1981–1982 (Speight 2003, 158). Even in 1999–2000, when questions about its future were emerging, it was concluded that 'archaeology is still thriving according to recruitment statistics' (Speight 2002, 82).

Looking at the statistics for the final years of Tony's tenure it is interesting to see that the annual programme of courses was very similar in size to what it was when he began. There were about 95 archaeological courses in 2003–2004, compared to about 100 in 1973–1974. That's quite an achievement bearing in mind that the growing government reluctance to fund universities for non-assessed adult education provision. The consequent lack of subsidy meant that the range of Tutorial courses, very much a stable component in earlier times, was generally much reduced.

Though in 2003–2004, Tony's final year before retirement, enrolment on a two-term 28-meeting Diploma or Certificate class cost about £175, up from about £3 in 1973–1974, there were now 37 such courses which is rather more than the 27 recorded for 1973–1974. The changes that Tony had introduced into the programme also meant that there was now a greater number of field and finds courses and, from 1998 onwards, a two-year part-time MA with an emphasis on archaeological practice. Tony had also established a 'Birkbeck Environmental Archaeology Group' (BEAG), so that his ex-students could continue to develop their studies and report on the fauna and flora deriving from excavations. I think that in the tribute below, provided by three of them who had become leading members of BEAG, the quality of his contribution to their learning is movingly conveyed.

Tony Legge and the Bone Room

Nick Bateson, Mike Hacker and Geraldine Missig

Tony was not one of those gently retiring persons. His presence continued to dominate the Birkbeck Bone Room even after he had moved to the McDonald Institute. From the bone-sorting trays and bone-measuring implements which he had made with his own hands to the leather-inlaid tables that he had rescued from Senate House when the authorities were replacing them with modern plastic tat, everything in the room had his characteristic stamp. The room itself was the product of his hard-fought fight for an archaeology workroom in which students could put into effect what they had learned from their lectures. Its most striking feature to a newcomer was the array of bones the full length of the longest wall, facing you as you entered, running from desk height up to Tony's maximum reach (very close to the ceiling), all prepared by himself or his students. From right to left here were the limb bones of the large and medium-sized animals that his students had to learn, from a Shetland pony down to a domestic dog that he had found in a ditch in Spain. Further along the wall to the left were the vertebrae and ribs of the same specimens. The bones of the smaller creatures were kept in a filing cabinet, including one that he was particularly proud of – a hare that his son had shot with an airgun that he had just received as a birthday present. Among his more exotic species were a Palestinian gazelle and a Syrian hare. Although he took most of his specimens away he kindly donated some to his successors in

the room, who continued to prepare their own specimens and to teach bone recognition and recording to a new generation.

One of his concerns was that the environmental evidence in the field was often overlooked. In his early days he had been involved with Cambridge colleagues in the development of wet-sieving tanks that are now widely used for the analysis of environmental samples. But these techniques tend only to be used on selected samples and to recover very small finds. He was aware that much potential evidence was missed on site and saw the need for the wide use of coarse dry sieving and while at Birkbeck led the development of a novel sieving frame. As well as being efficient, comfortable and safe, the sieve frame was designed to be light, demountable, low-cost and easily made by any competent handyman. With such equipment, all the material from a site could be sieved and much backbreaking work could be avoided. These frames were used on Birkbeck training excavations over the last twelve years and on excavations he was recently involved with in Croatia and Libya.

He delivered his lectures without notes and at a fast clip, and they were full of challenging, contentious ideas. When students asked him to leave a drawing on the board longer so they could copy it, he would immediately delete the drawing, saying 'you must learn to work faster'. He would warn students about the 'Chinese whisper' effect on ideas being lazily repeated down the years. He regularly set bone identification tests including some quite easy but others very difficult though they appeared easy. He wanted his pupils to have to think and to join him in challenging received ideas, methods and results. He had no use for a bone report in isolation from the rest of the evidence from a site. We were to think of ourselves as archaeologists first and foremost, using the environmental data as simply one strand of evidence. Specific memories of Tony come crowding back. One followed the discovery in an Irish glen early in 2000 of an animal with two bullet holes in its skull, which was portrayed in a national newspaper under the headline "Is This Shergar?" Tony's response to the editor was: "Not unless Shergar was a cow!"

Envoi

It is clear that by the time of Tony's retirement in 2003, the conditions nationally for the provision of University based adult education courses for part-time students were becoming less favourable and a process of change had begun which was to accelerate rapidly in the following years.

A Council for British Archaeology Survey published in 2009 (Lee 2009, 3) reported that, though 39 UK universities had been undertaking archaeological courses for adults in 1999/2000, the number had dropped to 28 (or by nearly a third), by 2008/09, while the courses on offer had fallen from 1327 to 515 (or by approaching two-thirds) over the same period. What's more, the survey suggested that three more universities, Manchester, Bristol and Reading, were planning to close their specialist adult education departments in 2009. Birkbeck can be added to that list: in 2009 in a College re-organisation it closed its Faculty of Life Long Learning, the last manifestation of the old Department of Extra-Mural Studies.

The changing basis of the Government grant to Universities and their own rising internal costs, both driving fees upwards, were two of the factors which help explain the survey's findings. If it was updated to the present, it is likely we'd find that this process has continued, with even fewer extra-mural departments surviving, a diminished number of universities offering archaeology courses for adult learners from relevant internal departments and a continued reduction in the number and range of courses, though at greatly increased prices. The landscape therefore is now very different and much that was successfully built up and maintained during the later 20th century has now disappeared.

Tony clearly found all this very depressing, viewing the diminishing opportunities for adults to

study archaeology as destroying what he'd worked to achieve. One personal consolation though was the opportunities offered to him after retirement to continue advising students in a new role, as a Senior Fellow at the McDonald Institute for Archaeological Research in Cambridge. The shock and sadness there that followed Tony's death showed how much he was still able to offer students seeking knowledge and how irreplaceable to all of us he is.

Acknowledgements

For many years Tony used to stay with me and Wendy McIsaac when working in London. I'm grateful for all the help she has given me when writing this article. I would also like to thank Elizabeth Charles, Head of E-Services and Systems and Stratford Librarian at Birkbeck, Richard Temple, the Archivist at Senate House and his equally patient colleagues in the library, Robin Densem and Geraldine Missig.

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‘The lowing herd winds slowly o’er the lea ...’ Tony Legge and the origins and spread of animal husbandry

Andrew M. T. Moore

Preliminaries

Anthony J. Legge, known to everyone as Tony, was among the most distinguished archaeozoologists of our time, and a strong-minded, larger-than-life colleague and friend. Tony’s death early in 2013 is all the more poignant because he was energetically pursuing research on an array of projects and publishing the results until the end. In a very full life he accomplished much: methodological advances in archaeology and archaeozoology; contributions to our understanding of the later prehistory of Britain, Spain, south-east Europe, Egypt, and central Asia, especially from the perspective of economy; and a highly successful career as a teacher and administrator at Birkbeck College in London. But it was his fundamental work on the origins of animal domestication in western Asia and the spread of an agricultural economy to Europe that were of global importance, and it is on these that I shall concentrate in this essay. The focus will be on Tony’s contributions to our collaborative research at Abu Hureyra in Syria, and in Dalmatia on the Adriatic coast of Croatia.

Our collaboration began in February 1972 and continued to his death, a span of 41 years to the month. It provided ample opportunity to see Tony at work in circumstances when the sun shone, and also when it did not. What follows are a few thoughts about him and his achievements derived from that lengthy partnership

Tony was deeply engaged with intellectual inquiry throughout his career, whether it was the research topic under discussion or other studies and interests of his that, sooner or later, would yield insights germane to furthering his scientific priorities. His timetable for producing results was not always that of his research colleagues but in the end he came through. The long list of items in his bibliography is testimony to this. It illustrates a certain stubbornness of character that carried him along the ups and downs of a varied career with multiple demands on his time. Tony had a strong practical sense, derived in part from his upbringing. He began working in his teens when he took a job as a technician at the Institute of Animal Physiology at Babraham near Cambridge. This gave him ample scope to develop his knowledge of the hands-on side of animal rearing, and farming more generally, a distinct element in his approach to the analysis of archaeological faunal assemblages later on. He knew farm animals and the rhythms of farm life; it is no coincidence that he chose to live his entire life in a country village. He was also a naturalist in its traditional British sense, with a keen understanding of

wild animal behaviour and even botany.

Tony was a methodological pioneer who developed a number of innovations in faunal analysis that I leave to others more qualified than me to review. He always thought of himself, however, as a field archaeologist as much as an archaeozoologist so it is fitting that almost the first and last papers he published in his lifetime were about innovations in field recovery devices, froth flotation and sieves (Jarman *et al.* 1972; Legge and Hacker 2010).

Time spent with Tony in the field was always illuminating (Fig. 3.1), for he had much to say about the scientific research that was the subject of our joint endeavours. He also was not slow to pass on observations about his fellow scientists, university colleagues, political affairs and much else. He was very generous in his sentiments towards those, few, people whom he respected but often acerbic in his judgements of others. This carried a personal cost, for some had difficulty seeing the scientific strength beneath the bluster and kept at a distance, which had an impact on the course of his career. It gave him all the more quiet delight, then, when Birkbeck College awarded him a personal chair.



Fig. 3.1. Tony Legge instructing in the field. Danilo, Croatia, 2005.

Given the vagaries of his personality, it may be surprising to some to learn that he was a very good team player. This was all the more so when he felt that his peers in the group were every bit as expert in their fields as he was in his. The team of collaborators that we built to carry forward the Abu

Hureyra project, still intact at his death, was the best example of this.

The Abu Hureyra collaboration

The decision to excavate Abu Hureyra arose directly from an invitation extended by the Syrian authorities in 1971. The Syrian government was constructing a dam across the Euphrates River that would flood 80 km of the valley, drowning many archaeological sites (Moore *et al.* 2000, 19). The Directorate General of Antiquities and Museums in Damascus mounted an international campaign of salvage excavations to recover as much information as possible about these sites before they were lost. Abu Hureyra clearly dated from the early Neolithic and, given its enormous extent of 11.5 ha, had the potential to yield even earlier remains. Such a site had never been excavated before in this region. It promised to tell us much about the early stages of agricultural development in western Asia. Accordingly, I decided to conduct the excavation to the highest prevailing research standards (Moore *et al.* 2000, 36). This meant that I needed to build a research team well in advance of the beginning of fieldwork and to incorporate their suggestions in the research design. On our way back from Syria to Oxford in 1971, I invited Gordon Hillman to join us as our archaeobotanist and he agreed. Then in February 1972 I went over to Cambridge, attracted by the innovations in theory and methods then being pioneered by the British Academy Major Research Project in the Early History of Agriculture led by Eric Higgs and of which Tony was a member. My immediate aim was to find out about the froth flotation machine the team had developed. This led to a conversation with Tony in which he not only shared all the construction details of the Cambridge machine and of the sieves that he was using but also offered to analyse our animal bones. Neither of us could have imagined then what a mammoth task that was to become.

The dig proceeded as planned through two lengthy seasons, in 1972 and 1973. All the excavated soil was dry sieved and massive quantities of sieved soil were processed in the flotation machines. This systematic approach to recovery yielded two metric tons of animal bones, an unprecedented quantity. We knew from the outset that most of the analysis of the material recovered from Abu Hureyra would have to take place after the dig had ended and the site had disappeared beneath the waters of the lake created by the dam. Under a special arrangement with the Syrian authorities, all the animal bones were shipped to England for study and final curation.

Tony had been unable to join us in the field because of other commitments. As soon as the first batch of bones arrived in England, he set to work analysing a sample of them and published the results in our preliminary report (Legge 1975). The sample Tony studied was a small portion of the total, just 2,500 bones, but it yielded important initial insights. He identified two patterns of animal exploitation at the site, an early one based on heavy exploitation of Persian gazelles (*Gazella subgutturosa*) and a later one in which sheep and goat predominated. The former was characteristic of Abu Hureyra 1 (Epipalaeolithic) and early Abu Hureyra 2 (Period 2A, early Neolithic) and the latter of later Abu Hureyra 2 (Periods 2B and C, middle and later Neolithic). He also identified enough bones to begin to construct a substantial species list.

As the analysis continued, it became apparent that the collection was of major significance for understanding the development of animal husbandry in western Asia. This was because of the long span of occupation at Abu Hureyra, extending from the Late Pleistocene well into the Holocene, and the enormous size of the animal bone collection. Tony decided to embark on a major analysis of all the bones and successfully sought funding to pay for it. A substantial grant from the Science and Engineering Research Council in Britain from 1982 to 1985 gave the project the momentum it needed. Tony recruited Peter Rowley-Conwy to help with the analysis and together they made huge progress in

making sense of how the ancient inhabitants of Abu Hureyra had exploited animals over time.

In order to understand more fully the behaviour of the key species in the faunal collection from Abu Hureyra, Tony with Peter Rowley-Conwy and Gordon Hillman travelled extensively through the Syrian interior in the spring of 1983. This yielded fresh insights about which animals, wild and domestic, were still extant in the region and how they were exploited. But, given the reduction in the numbers of gazelles and other species through hunting with modern firearms, more information was needed. Tony undertook an extensive investigation of the reports of early travellers in the region and this enabled him to reconstruct patterns of migration for gazelle and other species in the past, as well as traditional methods of hunting. He also spent time in Moscow in 1985 at the Lomonsov Museum of Zoology studying teeth recovered from one of the few populations of Persian gazelles that survived in some numbers in the wild to establish their seasonality. These studies culminated in an important article by Tony and Peter (Legge and Rowley-Conwy 1987) in which they described in detail the nature of gazelle hunting at Abu Hureyra and its extraordinary persistence well into the Neolithic. The article provoked considerable debate, even scepticism, at the time among those unused to such novel thinking but its conclusions are now broadly accepted.

Completing the analysis and writing-up took several more years, partly because Tony was engaged in a number of other projects at the same time. An important goal was to integrate his findings from the animal bones with all the other categories of evidence from Abu Hureyra. Beginning in 1986 and extending for another decade, Gordon Hillman and I met with Tony in the bone room at his office in Russell Square in London whenever I came to London, usually a couple of times a year. We were often joined by Peter Rowley-Conwy and Theya Molleson whom Tony had also encouraged to join the team to study the human remains from the site. These meetings were extraordinarily productive and an important reason why we were able to publish a comprehensive, integrated account of the development of the settlement and its economy (Moore *et al.* 2000).

Tony's contribution to all of this was fundamental (Moore 2003, 72). He described the array of species that was likely to have been present in the region in the historic past and so available for humans to exploit (Moore *et al.* 2000, 85). Then there was the exploration of the nature of the economy through time and the question of seasonality. He was able to tie these elements to the development of the settlement itself and its changing configuration. All of this was given unusual precision through the accumulated radiocarbon dates for the sequence of occupation, most of them from AMS dating, one of the first demonstrations of the power of this technique. In order to extract the necessary information from the data, he and Peter had to develop new techniques of analysis, another major contribution to archaeozoology (Legge and Rowley-Conwy 2000).

Once we understood that Abu Hureyra was on a gazelle migration route, it became clear that this had been a key factor in the selection of that location for settlement. It also helped to explain the subsequent persistence of the village there through major episodes of climatic change. Abu Hureyra began as a settlement of hunters and gatherers around 13,500 cal BP. The main source of meat was gazelles that passed by the site every spring during their migration. The inhabitants killed them using animal traps. Six hundred years later, c. 12,900 cal BP, there was an abrupt change in climate as the Younger Dryas set in. This was the catalyst for the adoption of cultivation of domestic rye, other grains, and several legumes. This marked the beginning of agriculture. Hunting persisted, however, until much later times with gazelles as the main source of meat, presumably because they were present so reliably every spring.

By the beginning of Abu Hureyra 2, c. 10,600 cal BP, and probably even earlier during the Intermediate Period (c. 11,500–10,600 cal BP), domestic sheep and goat were being raised at Abu Hureyra, yet gazelle continued to be exploited heavily. It is possible that the sheep present in Abu

Hureyra 1 were also under human control, given recent trends in the evidence (Zeder 2011). I once asked Tony about this; he was not opposed to the idea but simply said that there were too few bones to tell. The emphasis on gazelle hunting for the supply of meat persisted until c. 9,300 cal BP. Then suddenly the sheep and goats, which had been less prominent hitherto, largely replaced the gazelles. This was almost certainly because of an increase in predation by people living along the migration routes (Legge and Rowley-Conwy 2000, 471). With the addition of domestic cattle and pigs around the same time, the people of Abu Hureyra had developed a mature mixed farming economy recognisably like that of the near present-day in the region.

Tony's analysis of the animal bones from Abu Hureyra was a fundamental contribution to science. The sample available to him was massive and his study of it was meticulous. The sequence of occupation at the site was lengthy, lasting for some 6,000 years, was continuous, and precisely dated. It extended from the Late Pleistocene well into the Holocene and so encompassed several major episodes of climatic change. The conclusions that he derived from his multi-year engagement with the sample, and all the ancillary studies that he undertook, were unusually solidly grounded. We should remember, too, that these new insights came from a region about which almost nothing had been known before. Yet it was of crucial importance to our understanding of the development of animal husbandry and farming because it linked the Levant with northern Mesopotamia, the Zagros Mountains, and Anatolia. We now have a quite different understanding of the development of animal husbandry in western Asia than we did 40 years ago because of Tony's research. Continuing investigations by others in the region, in the Zagros Mountains and, most recently, in Cyprus, have demonstrated the soundness of his interpretations (Vigne *et al.* 2011; Zeder 2011).

Tony intended to renew his study of the animal bones in retirement. He planned to continue the analysis of those trenches not yet examined in detail, to investigate patterns of butchery and also to identify specific activities from levels where preservation allowed it. And he also intended to re-measure all the bones to ensure the most accurate assessment possible of their dimensions, this with future generations of archaeozoologists in mind. With the support of a Leverhulme Fellowship he made a start on this ambitious project but it remained incomplete at his death. He had informed us that there was a noticeable increase in the incidence of cattle in the latest Neolithic phases at Abu Hureyra but the details remain to be revealed. It is our hope that in the years to come others can continue this research where Tony left off. The collection of bones from Abu Hureyra is safely curated at the University of Cambridge and will be available for future analysis. Peter Rowley-Conwy has agreed to oversee the collection.

Dalmatia

The Early Farming in Dalmatia Project began in 2000 when our colleague Marko Mendišić, then Senior Archaeologist in the Šibenik City Museum, invited me to join him in an archaeological collaboration (Mendišić and Moore 2013). Our intention was to undertake a project that would investigate the inception of farming in Dalmatia. It would serve as a case study of the process of agricultural spread from western Asia through the Mediterranean into southern Europe. We have conducted test excavations of two Neolithic sites in the region, Pokrovnik and Danilo, using recovery methods that have ensured maximum recovery of bones and charred seeds as well as artifacts. We are examining the development of farming at these two sites and across central Dalmatia in the context of the changing environment of the region. The main fieldwork took place over four years from 2003 to 2006, and the landscape and other analyses are still in progress.

Given the excellent working relationships we had developed over so many years of research on

the material from Abu Hureyra, I invited several members of that team to join me in the new project in Dalmatia. Tony immediately accepted my invitation and also volunteered to join us in the field in each of the main excavation seasons, 2004, 2005 and 2006. He retained fond memories of participating in Ruth Tringham's dig at the Vinča culture site of Selevac in the Former Yugoslavia (Legge 1990), and wanted to find out how the early farming economy of the Dalmatian coast differed from that in the Danube Basin. Our Croatian colleagues in this international collaboration have been full contributors to the research from the beginning (Mendušić and Moore 2013). We have also welcomed other younger scholars to the team to ensure involvement of a new generation in the research.

Tony's presence on the dig marked an important difference with the research at Abu Hureyra. He was able to tabulate and analyse the bones from our excavations on the spot. This greatly simplified their study. Furthermore, Tony could give us a preliminary indication of the trends in the data immediately as the excavations proceeded. The assemblages of bones were then deposited in the regional museums in Šibenik and Drniš for curation at the end of each season.

By the time our fieldwork in Dalmatia was moving ahead briskly, Tony had retired. This enabled him to complete the preliminary analysis of the fauna from Pokrovnik and Danilo swiftly and to publish the results (Legge and Moore 2011). All four key domestic animals were present from the beginning, sheep, goats, cattle and pigs. Sheep, with some goats, were by far the most numerous animals. Wild species were minimally present, and the bones of these came mostly from small animals. These data, together with the abundant evidence for cultivation of domestic crops, indicated that we were dealing with an agricultural economy that had been developed elsewhere. It had been brought to the Dalmatian coast, presumably by immigrant farmers. From the numerous AMS dates we obtained for Pokrovnik and Danilo, we know that this happened around 8,000 cal BP. There were no indications of an initial transitional or 'settling in' phase. Instead, it appears that the new way of life was immediately adapted to the ecological parameters of the Dalmatian environment. Thus, Tony's analysis demonstrated unusually clearly that the arrival of farming in Dalmatia represented a new economic system and a decisive break with the past.

Fortunately, Tony had time to publish this in considerable detail. He had also drafted a substantial contribution to an interim report on the entire project that is in preparation. So his key insights are already in the public domain. We have access to Tony's detailed records of the bones and, of course, the faunal assemblages themselves are available for continued research. Again, we had all hoped that Tony would carry out the more detailed studies of these collections that he had planned, and integrate the results with the rest of the analyses that are currently under way. This task will now be undertaken by others.

An assessment

Tony Legge died while still working productively at his full intellectual capacity. Throughout his long career in archaeology he stressed the importance of careful, systematic recovery of material evidence. Tony himself developed a number of significant technological advances, among them froth flotation machines and sieves. His latest model of sieve was tested at our excavations in Croatia (Legge and Hacker 2010) and continues to serve well there in the field.

Tony's very many years of service to advancing the science of archaeozoology enabled him to develop new insights on animal bone identification. He also proposed a number of methodological advances in their study, including techniques for aging animals from their teeth. These contributions, based on detailed study of faunal collections from across Eurasia, were significant and substantial. They demonstrate that he derived important scientific insights from his extensive travels. For all that he

wanted you to infer that he carried the traditional prejudices of the Englishman on his journeys, he relished opportunities of spending extended periods abroad in the field, observing and absorbing information about the natural world and traditional farming wherever he went.

Among these many insights, those pertaining to the inception and initial development of animal husbandry were of lasting significance. He was fully aware that humans had interacted intimately with wild animals in the later Pleistocene, an understanding that was an important guiding principle for the British Academy Research Project. But he saw sooner than most that human control of selected species of animals leading to their full domestication began very early in western Asia, much earlier than his contemporaries believed. This was closely tied to changes in environment and human ecology in the prolonged, uneven, transition from Late Pleistocene to Holocene. It is an insight that some still have difficulty in grasping.

Notwithstanding, he also appreciated better than many that wild animals could contribute to human economy long after agriculture had become the mainstay of life. His research at Abu Hureyra and Selevac highlighted this most clearly.

The transmission of farming from western Asia to Europe preoccupied Tony throughout much of his professional life. He was an early exponent of the view that agriculture developed as a complete system in western Asia. It was this relatively mature agricultural economy that was taken to Europe by farmers on the move. For him all this was clear enough from an early stage of his career (Legge 1989) and our research in Dalmatia confirmed this understanding in the clearest possible manner. To Tony the spread of farming, and especially animal husbandry, across Europe, ultimately to the British Isles, represented a decisive departure from what had gone before.

Tony had more to contribute to our understanding of the ways in which humans exploited animals for food, and much else besides. As he progressed from one project to the next there was little time to explore in depth the full implications of the data he analysed. He intended to do this, however, for Abu Hureyra and the Dalmatian sites in the years to come. We must now complete the work he began and carried forward so far.

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Reflections in a dustbin: froth flotation and origins of rice cultivation in South-east Asia

Charles Higham

Introduction

Eric Higgs was a latecomer to prehistoric archaeology. A graduate in economics, he owned a sheep farm in Shropshire before coming to Cambridge to study prehistory under Grahame Clark in the 1950s. In due course, he was appointed to a junior faculty position as an assistant in research, and from this modest base, began to assemble a collection of modern animal bones in order to facilitate the identification of prehistoric faunas. At that juncture, many archaeologists paid little attention to animal bones, and some did not even retain them when excavating. Eric, however, enthused a generation of aspiring prehistorians into the importance of reconstructing early economies, at a time when material culture dominated instruction. Indeed, he taught at a time when radiocarbon dating was in its infancy, and artefact typology was a principal means of establishing chronologies across Europe and the Near East.

Eric spent much of the day in what came to be known as ‘the Bone Room’, and would focus his piercing blue eyes on one while intoning some of his favourite asides, such as: ‘I will tell you more about a prehistoric society from one animal bone, than from a case of hand axes’. I was one, possibly the first, of his PhD students, and spent many months in museum vaults both in Switzerland and Denmark, identifying and interpreting faunal remains stored from earlier excavations. On completing my doctorate, it was Eric who guided me to apply for a lectureship in New Zealand. After a 5 week ocean voyage, my wife and infant son Tom arrived in Dunedin in January 1967, to the world’s most southerly University, where I set myself up as a Higgs clone by beginning to assemble a comparative collection of modern New Zealand faunal remains before embarking on a brief foray into the prehistory of the South Island.

After 3 years, I returned to Cambridge on a sabbatical leave and naturally visited Eric and the bone room. It had undergone a transformation. Eric was now directing a British Academy-Royal Society research programme on the origins of agriculture, with a deputy director Mike Jarman, and a dedicated team of graduate students. One of these was a mature student, Tony Legge, and I recall distinctly our first meeting, when he took me into an adjacent laboratory to reveal what looked like a large circular metal dustbin, attached to a series of pipes. This, he explained, was the flotation machine. He turned on a tap or pump, and frothy water bubbled up to flow through a chute into a series of

graduated Endicott soil sieves. The bubbles, he explained, attached themselves to light organic matter in excavated material, and were captured in one of the sieves. Eric's project had graduated from animal bones to the full gamut of microscopic biological remains that had hitherto defied collection and analysis.

Applying the flotation machine

Where Tony Legge would apply this device in Europe and the Near East, in an innovation that would become standard practice, I returned to my first season of fieldwork in what was to me, a new and virtually unexplored territory in Thailand.

My first campaign involved very small excavations on a miniscule budget, with no opportunity to apply any form of flotation. At Banyan Valley cave in 1972, I worked with Chester Gorman. Again, there was no opportunity to transport a flotation chamber into a cavern so remote, that it was quite hard enough to walk along jungle trails for many hours. But we did dry sieve a sample of the material we excavated, and thus collect a good sample of rice chaff. At the time, we thought that we had identified the pathway to rice domestication, then described as the \$64,000 question of South-east Asian prehistory, but the rice turned out to be wild, and the context from which it came was very late. At Ban Chiang in 1974–1975, again, under the direction of Gorman, we used screens but what we found is not known to me since our excavations have never been published.

In 1981, however, I was in a position to direct my own excavations at the prehistoric site of Ban Na Di, and I was determined to use a flotation chamber. At that juncture, we were still trying to recover plant remains, particularly rice, since the timing and the location of domesticating this vital plant were unknown. We had a flotation chamber constructed locally, and bought the necessary plumbing and a pump. When we encountered difficulties starting and operating the pump, my Thai assistants began to dissect it with an air of technical assurance until it lay in its component parts. However, they were quite unable to reassemble it. So I had to follow plan B. This entailed a very fine mesh, and passing through it a sample of all our excavated material. My son Tom assisted in this endeavour and the results made all the effort involved worthwhile. We were able to pick out of the retained residue, a considerable sample of carbonized rice grains, which were dispatched for analysis to the International Rice Research Institute in the Philippines and were duly reported as being from a domestic plant (Chang and Loresto 1983). Of equal significance was a large assemblage of minute bones, most of which came from fish. In the few previous faunal reports on Thai prehistoric sites, fish hardly featured. But at Ban Na Di, they dominated numerically. The layers in this site also contained several lenses of clean sand, of the sort laid down by floodwaters, and when we consulted the older inhabitants of the village, we learned that the large Lake Kumphawapi, now 15 km to the west, used to flood the site, bringing fish to the doorstep. The lesson learned back in the bone room was leading to a re-evaluation of the subsistence base of Bronze Age Thailand, albeit involving much hard manual processing.

Khok Phanom Di

As I completed the excavation of Ban Na Di, I was taken by Thai colleagues to a newly discovered site called Khok Phanom Di. This large mound is located about 50 km east of Bangkok, and I resolved on my first visit, that when I had published Ban Na Di, I would try and secure the funding and the permit to excavate there. This was to be the proving ground of the flotation machine. Khok Phanom Di sits like a stranded whale on the flood plain of the Bang Pakong River. When we first visited the site in

1982, the small excavation square opened by a local teacher was still open, and with a bamboo ladder, I climbed down into the inky depths, passing as I did, the occasional human skull looking out from the side walls until at a depth of about 10 m, I came across a shell midden, and then the natural substrate. Damrongkiat Noksakul, who had led the excavation, told me that he had found rice grains there, and I composed a model that I hoped would appeal to granting agencies, that this site might contribute to understanding the origins and spread of rice domestication. A couple of years later, I had the remarkable good fortune of staying in the same hotel in Bangkok as the director of the Ford Foundation for South-east Asia, and over dinner, I outlined my plans and hopes for Khok Phanom Di, and he was to respond with two training grants which guaranteed sufficient funding. I then was given the vital permit to excavate by the Thai authorities, and my Thai colleague Amphan Kijngam had a roof constructed to allow us to open an area of 10 × 10 m. With excavations due to commence in December 1984, I received a letter from an ethnobotanist, Jill Thompson, asking if she could join the expedition. I willingly agreed.

We had a flotation machine constructed locally, and this time under her experienced guidance, it was soon operational. Jill was to work on the flotation from 27 December 1984 until we reached the natural substrate on 17 July 1985. Our excavation in the centre of the site encountered a cultural stratigraphy 7 m deep (Fig. 4.1). We uncovered seven phases of human burials dating between 2000 and 1500 BC, in which the dead were interred over the ancestors in a span of about 20 generations. A critical aspect of our research was to reconstruct the environment. Without our flotation machine we could never have succeeded, for the recovery of biological micro-remains surpassed our most sanguine expectations. When possible, I would leave the excavation square to Jill's workplace on the edge of the mound to see what was being recovered. Essentially, these finds fell into several categories. There were, first and foremost, the plant remains including seeds, fragments of charcoal, rice husks and mineralised wood. Many tiny bones were floated, including those of fish and small mammals. Fish scales and insect remains survived, as well as minute shellfish.

The analysis of the plant remains was undertaken by Jill Thompson. She found that all the layers in the site produced seeds, with the highest concentration reaching 65 in a 10 litre sample. These allowed a reconstruction of the environment and identified changes over the half millennium during which the site was occupied (Thompson 1996). The seeds represented three specific habitats. The first, documented by the presence of the plant *Sueda maritima*, comprised an open salt marsh, typically located behind the coastal mangroves. The second involved shallow fresh to brackish water swamps, which provided in her samples, the achenes of the grass-like Cyperaceae. Finally, there was a dry land habitat. To these should be added the plants that flourish following human disturbance such as *Amaranthus* and *Portulaca oleracea*, which probably colonised the mound itself. Much charcoal was also recovered, and initially it was dominated by the mangrove *Rhizophora*. The combined evidence suggests that the site was initially located on the Bang Pakong River estuary, within the mangrove zone, backed by an open, saline plain. This is not the habitat that would have encouraged experiments in rice cultivation, since this plant is not salt tolerant. Several of the plants identified however, such as the leaves of *Sueda maritima*, can be eaten. But from the 8th layer, the mangrove indicators fell sharply, to be replaced by more fresh water indicators.

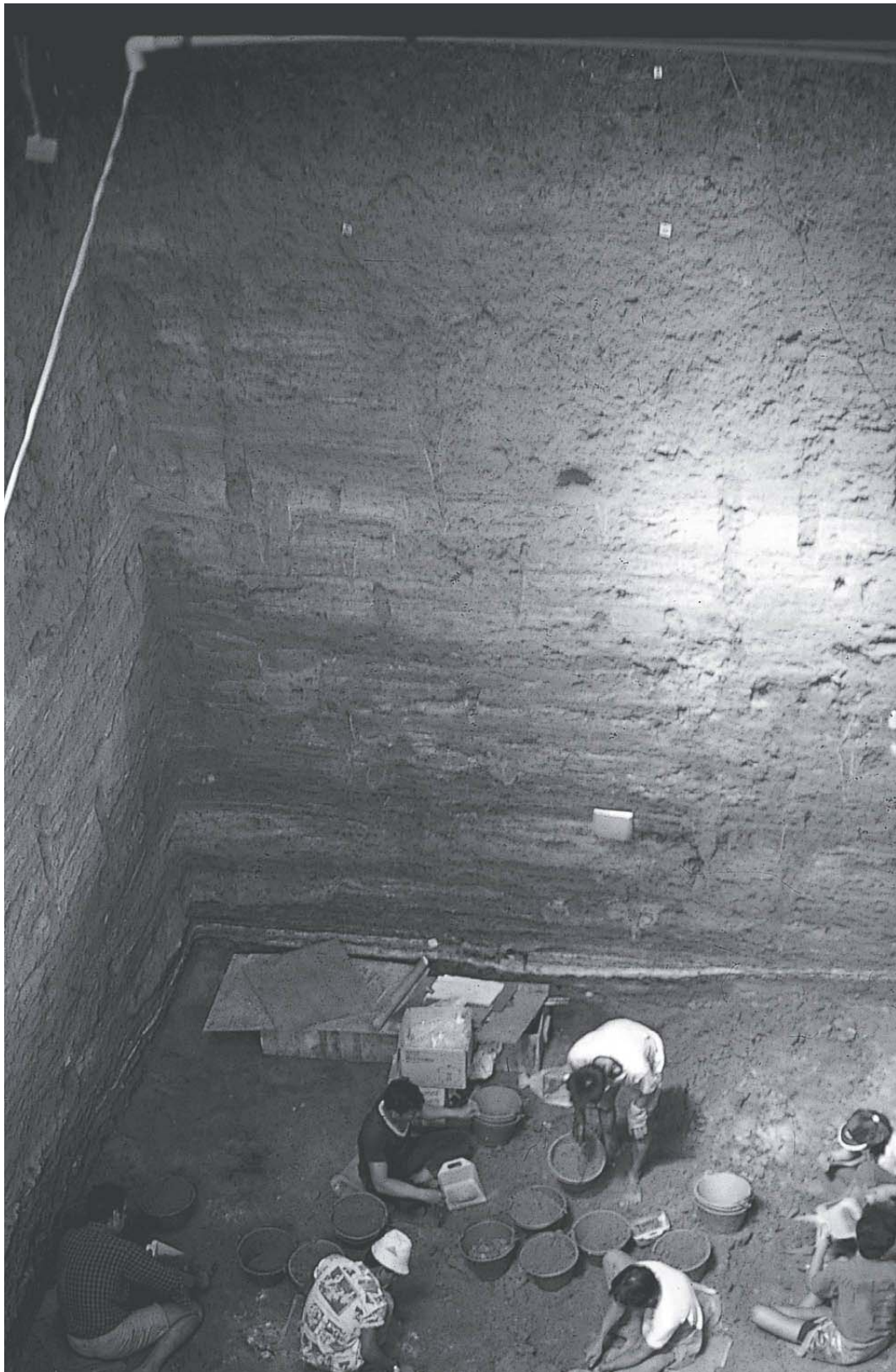


Fig. 4.1. The stratigraphy at Khok Phanom Di was very complex and deep. Every context was sampled by wet sieving.

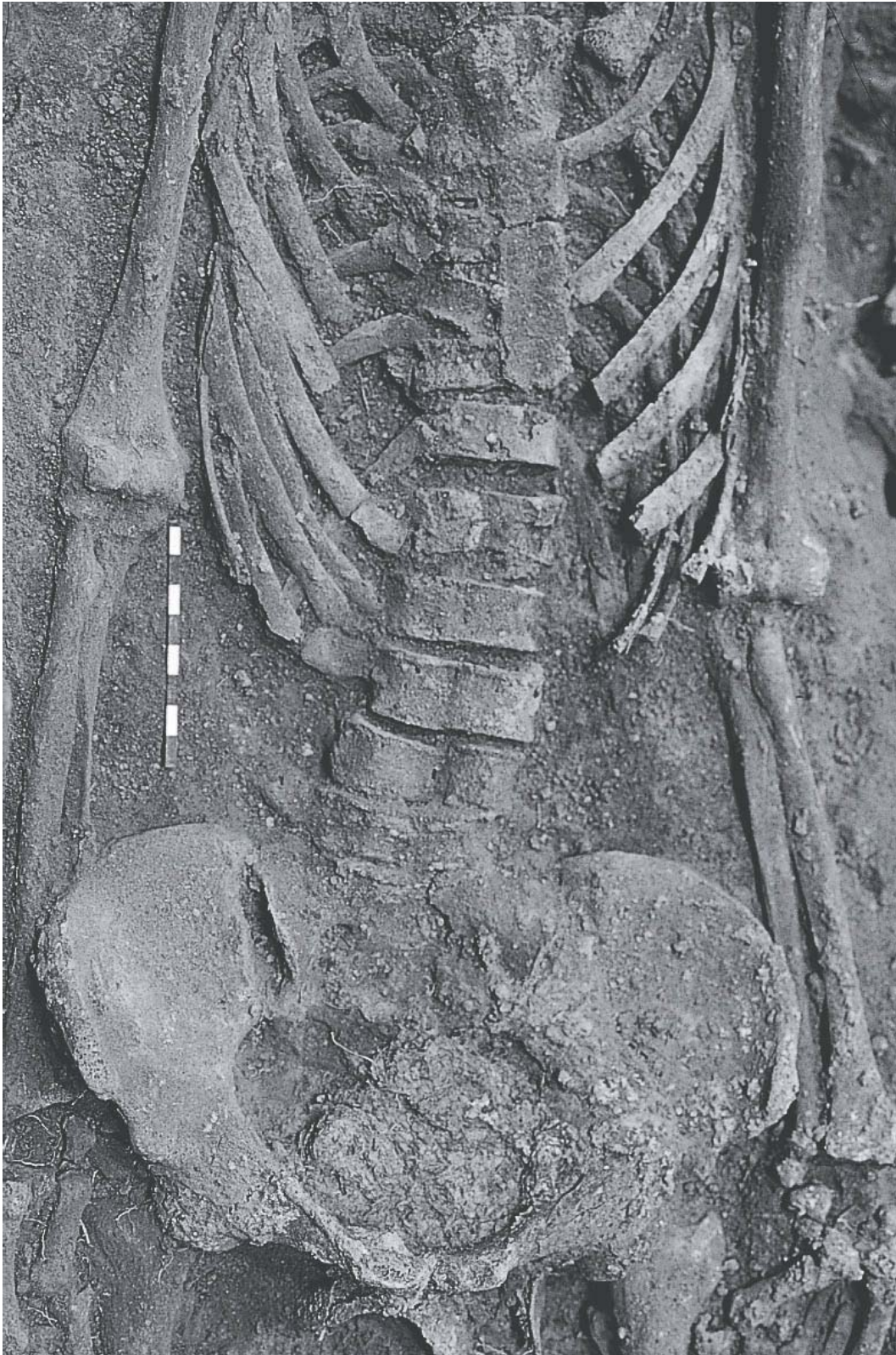


Fig. 4.2. The woman in burial 56 at Khok Phanom Di had a ball of partially digested food lodged in her pelvis. It contained fish bones, scales, and rice husks.

The identification of rice remains cut across this changing vegetational mosaic. Husk fragments were found in all layers at the site, but it was not possible to define them as from either a wild or domesticated plant. A handful of potsherds, made of clay exotic to the site, contained fragments of rice

but all other potting clay had been tempered with sand or grog. Only with the final occupation layer was rice widely used as a ceramic temper. For mortuary periods (MP) 1–3A, rice could have been collected wild from the margins of freshwater swamps within range of the site. However, the situation changed with MP3B–4. It was at this juncture, that the artefacts included large granite hoes and shell knives with cutting surfaces striated in a similar manner to modern experiments harvesting rice (Higham 1993). Two MP3B burials provided clear proof. Burial 56, that of a woman, included a block of partially digested food in the pelvic area (Fig. 4.2). It comprised a mass of fish bones and scales, and rice chaff. The grave of burial 67 contained faeces, and surviving rice included the abscission scars of a domesticated rice (Thompson 1996). The isotopes in the teeth of some of the MP3 women also indicate that they were raised in a different environment to that of Khok Phanom Di. They may have come to the site as marriage partners from a fully Neolithic, rice growing community in the interior (Bentley *et al.* 2007).

The sequel to this marked change, which saw freshwater indicators replace those of the mangrove fringed estuary, is reflected in the micro-molluscs that emerged from the flotation tank. In his detailed analysis of the thousands of tiny snails, Mason (1996) identified 43 species, as well as numerous land snail eggs. Modern comparative data relate most of these species to a preferred habitat. Thus *Stenothyra glabrata* prefers to live in intertidal brackish water creek, while *Assiminea woodmasoniana* is found in mangrove and nipa mudflats. *Bacillum* on the other hand, is a terrestrial species. These snails support the conclusion that the site was located in tidal-estuarine location surrounded by mangal until layers 7–8, when it was invaded by dry-footed land snails.

An issue with many of the micro-molluscs concerns taphonomy, for many almost certainly came to the site in fish guts, and the fish could have been caught some distance from the settlement. However, supporting environmental evidence comes from a range of other sources. With the end of the excavation, we took samples from the complete stratigraphic sequence on the eastern section, and submitted these to Ken McKenzie. He employed a wet sieve with a mesh of 63 μm , in order to recover minute organic remains. These included bryozoans, echinoderms, sponges and crustaceans, but his principal objective was the identifications of ostracodes and foraminifera. With a high powered microscope, he was able to name ten species of the former, and 20–25 of the latter (McKenzie 1991). These confirmed that the site was located adjacent to an active estuary with a low-lying marshy hinterland, but from layer 8 at least, there were local freshwater ponds.

Larger shellfish are perhaps the most informative of all sources for environmental change at Khok Phanom Di. In his detailed analysis of the 107 species recovered, Mason (1991) has assigned each to one of five major habitats: marine, mangrove, estuarine, freshwater and dry land. He then computed the frequency distributions for each of these on the basis of the species of shellfish identified through the occupation of the site. The distribution for species assigned to seaward facing mangrove conditions shows a peak during later layer 10, followed by a steady decline to layer 7, and then a rise in layer 6 before a second decline into layers 5 and 4. The converse is true for shells from freshwater streams, rivers and lakes. There were few species throughout layers 11 and 10, then sharp rise in layer 9 and 7, followed by decline in layer 6. Dry land shellfish were virtually absent until layer 7, followed by a consistent rise.

Several other microscopic organisms were recovered from Khok Phanom Di, including a helminth egg, mouse hairs, mites and insects, all of which illuminate aspects of life over the five centuries of occupation. Without the flotation chamber, our interpretation of this site would be severely blinkered, and testing our initial model that it was along the coast that rice was progressively domesticated would have been virtually impossible. This model failed when we were finally able to test it, and equipped with detailed palaeo-environmental information, it has been possible to present a

better-informed alternative. By relating the seven-phase mortuary sequence with the environmental information gained from flotation, we encounter first a coastal hunter-gatherer community of considerable sophistication, commanding a rich estuary. They made fine ceramic vessels, used polished stone adzes, and engaged in exchange with rice farming communities now settling the hinterland. During mortuary phases 3B and 4, some women from a different habitat came to Khok Phanom Di, at a time when the sea level fell, and freshwater conditions expanded in the site's orbit. At this juncture, domestic rice was cultivated with the aid of stone hoes, and harvested with shell knives. However, marine conditions returned with MP5 and 6. Hoes and harvesting knives disappeared from view, and hunting and gathering again dominated at a time when which saw the rise of very wealthy individuals whose social success was based on outstanding ability to manufacture ceramic vessels. One woman was interred wearing over 120,000 shell beads, another two were buried in a raised mortuary building. Increasing distance from the sea, evidenced in the rise of land snails and diminishing numbers of marine shellfish, would ultimately lead to the abandonment of a site that had sustained the same community for at least 20 generations.

The Khok Phanom Di programme benefitted from the fortunate participation of many specialists. Jill Thompson spent 7 months working on the flotation chamber, several of which involved the rainy season when drying specimens became a nightmare. Bernard Maloney took pollen cores, Graeme Mason spent years analysing the shellfish, and Brian Vincent took on the monumental task of analysing the ceramics. Ampham Kijngam studied the fish, crabs and turtles, Nancy Tayles the human remains and Alan Grant the mammals. Such cooperation and integration is the key to a successful archaeological enterprise in South-east Asia, and the flotation undertaken at Khok Phanom Di was crucial.

Nong Nor

Five years were to elapse before I returned to Thailand, to a new programme at Nong Nor, about 15 km south of Khok Phanom Di. We first encountered this site during a survey, when a local informant took us to a field where locals had been digging for land crabs. A metre down in one of their holes, we saw marine shells and prehistoric potsherds. A local landowner had also been unearthing human remains.

We had already identified a number of similar sites in our study area, all located on a broad flood plain under intensive rice cultivation. Again, good fortune came in the form of a letter from Dr William Boyd, a geomorphologist interested in joining our team. As we excavated Nong Nor, so he and a group of well diggers opened deep trenches in the surrounding landscape so that he could study the sediment sequence and take pollen samples (Boyd 1998). Meanwhile we spent three seasons excavating a site with two distinct phases of use. The earlier comprised a dense shell midden, dated by my son Tom to about 2300 BC (Fig. 4.3), a few centuries earlier than the initial occupation of Khok Phanom Di. The material culture matched closely that found in basal Khok Phanom Di: pottery vessels, polished stone adzes, and bone fish hooks. A much later Bronze Age cemetery had been cut down into this midden.

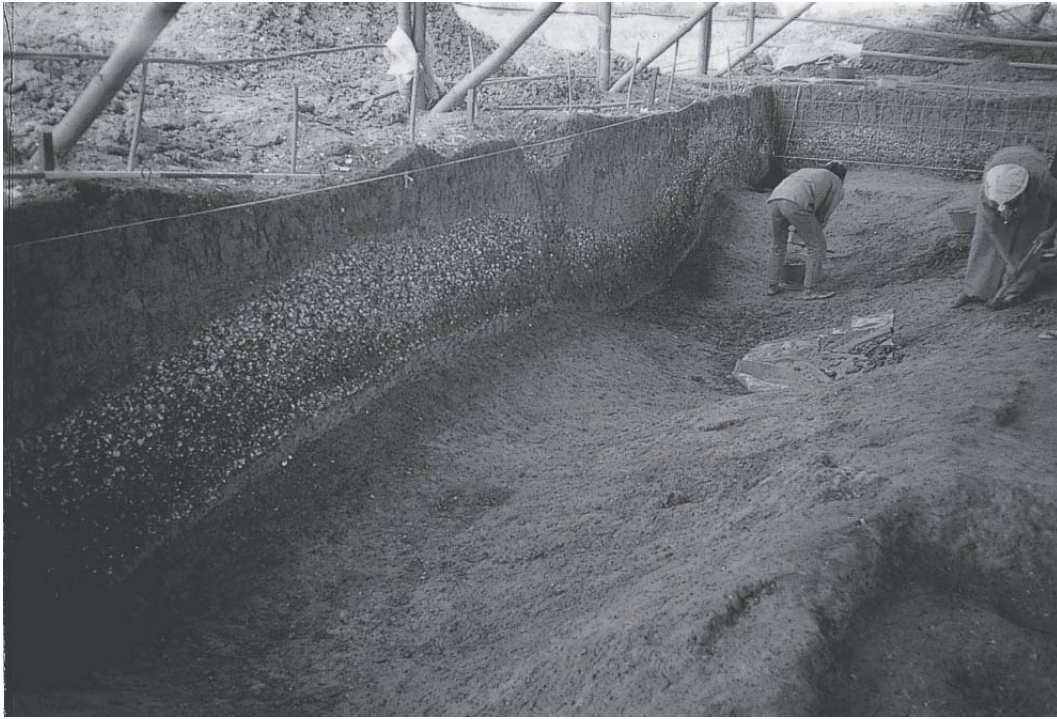


Fig. 4.3. Nong Nor comprised a shell midden, cut into by a later Bronze Age cemetery.



Fig. 4.4. Undertaking flotation at Ban Lum Khao. Jill Thompson is on the right.

We sought answers to two principal issues. What was the environment during the first phase, and what could the contents of the shell midden tell us about subsistence? Through his interpretation of the sediments, Boyd composed a map showing that Nong Nor had once occupied a low headland next to an indented marine embayment, with access by boat to the open sea about 3 km to the north. Quite independently, I superimposed on his map the location of the other sites we had identified, and each sat

neatly on the former shore of this embayment. As for flotation, Nong Nor had no supply of water. So we bagged shells directly into 50 kg sacks, together with those from the 1 cm mesh screens. We also took samples of each context, air dried them and then wet sieved through 1 mm screens in a nearby village with an adequate supply of water. There was an amazing dominance of one species, the cockle *Meretrix lusoria*, with 99.7% of the sample. It comes from a sandy ground just below low tide, and we counted 5,557,090 individuals. The second most common shell was *Anadara granosa*, with 12,064 valves, followed by 54 other species nearly all of which come from marine, mangal and estuarine habitats. Only two are adapted to fresh water, represented by just four shells, together with fragments of Unionidae.

Mason's detailed analysis of the shellfish has presented a settlement surrounded by sheltered mangroves near an open shore, thus confirming Boyd's geomorphological reconstruction (Mason 1998). The shell midden was not exclusively composed of shellfish. Thus the presence of dermal denticles and teeth indicate blue water fishing for weasel, whaler, oceanic white-tipped, tiger and bull sharks. Wet sieving also yielded the dermal denticles of stingrays and eagle rays. Since some of these sharks and rays grow to a considerable size, and are found offshore, Mason has suggested that there may well have been group fishing in substantial, ocean going vessels.

In many respects, our reconstruction of a coastal hunter-gatherer community in the late third millennium BC turned on the results of wet sieving samples taken from the shell midden. We concluded that the site was inhabited for a relatively brief period of time, measured in months rather than years. We excavated most of the site, and only one burial belonging to the first phase of site use was found, a woman in a seated flexed position under some pottery vessels. No hint of rice was found, nor any domestic animals. The community was clearly well adapted to their marine environment, which is hardly surprising given that their ancestors surely lived on the drowned shores of Sundaland for at least the preceding 50,000 years.

The Mun Valley

I had planned a fourth season at Nong Nor, but the Fine Arts Department decided to move my co-director, Rachanie Thosarat, to a new posting in Phimai. This town is located in the upper Mun River valley on the Khorat Plateau, and was formerly under the name Vimayapura, a major regional centre of the civilisation of Angkor. The Mun Valley is thickly populated with prehistoric sites easily identified by their surrounding moats and banks. My first excavation in Thailand in January 1970 involved one of these sites, and I seized the opportunity to move focus from the coast to the interior, and from hunter-gatherers to the Iron Age, and its transition into early states. After several seasons of site surveys in our chosen study area, we identified four sites for excavation, beginning in 1996 with Ban Lum Khao. Jill Thompson and Graeme Mason once again set up their respective flotation equipment, and worked alongside the excavation square, since this village had a plentiful supply of water: indeed a stream flowed past our site (Fig. 4.4). Disappointingly, no report has been received from either.

We moved on to open four further sites over a period of 15 years, all substantial mounds within their encircling moats and banks, and are currently involved in three seasons of excavations at one of these Non Ban Jak. We have taken samples from all for wet sieving, and the resulting accumulation of small fish bones and shellfish has greatly expanded our appreciation of the subsistence base during the occupation of each site. Ban Non Wat has the longest sequence, beginning in about 1700 BC with the initial settlement by Neolithic rice farmers, and proceeding through 12 mortuary phases to the end of the Iron Age. Noen U-Loke revealed occupation over the millennium of the Iron Age, beginning in the

fifth century BC, Non Muang Kao revealed successive house floors and burials dating to the later Iron Age, while Non Ban Jak again, dates to the late Iron Age. This research programme has as a major focus, the economic basis of Iron Age settlement, with particular reference to the methods of cultivating rice. Rice production was a key contributor to the establishment and durability of the civilisation of Angkor: we now know that the massive reservoirs at Angkor fed water through a complex system of canals into rice fields (Fletcher *et al.* 2008; Hawken 2011). Fixed fields and irrigation can be extended back into the period of Chenla statelets from AD 550–800, but how far back into prehistory can this system be traced? Permanent fields defined by low banks or bunds, ploughing with the aid of water buffaloes or oxen, and the safeguard of a water supply to irrigate fields if the monsoon rains falters, as it often does today, promote differential land ownership and the opportunity for social elites to emerge on the basis of wealth creation.

The evidence needed to identify the evolution of rice cultivation systems, at least in part, requires the recovery of rice, and its weeds of cultivation. In November 2012 we had a particularly lucky break at Non Ban Jak. Having excavated down through several superimposed Iron Age buildings and lanes, we uncovered the remains of a house that had been destroyed in a conflagration so intense, that it had fired the clay floors of the building, charred to foundation beams, and carbonised rice in an around the cooking hearths where plates were still in place (Fig. 4.5). After excavating through this building, which dates in the vicinity of AD 400, we encountered the remains of a kiln for firing pottery vessels. Half a dozen pots were still in place within, together with a large, socketed, iron implement which our workers immediately identified as a ploughshare. We had further good fortune because in the weeks following these discoveries, Cristina Castillo joined us to undertake a programme of flotation. Where it is usually the case that flotation will yield a modest quantity of rice if any at all, Cristina had grains by the sack full. The sequel is work in progress. We await laboratory analyses to see if the rice from this house was associated with weeds that grow in permanent wet fields. The ploughshare is one of the most significant pointers to agricultural intensification during the late Iron Age, a period when at Noen U-Loke, sickles were a further innovation that employed iron for agricultural tools. I then read Scott Hawken's doctoral dissertation and found that he has identified faint traces of late prehistoric rice fields radiating out from the moated site of Lovea, near Angkor (Hawken 2011). Thus several lines of evidence are trending towards a new model, in which the efficiencies gained from irrigation and ploughing in fixed fields were being secured during the prehistoric period and laying the foundations for sudden change towards the foundation of states.



Fig. 4.5. A house at Non Ban Jak had been destroyed in a fire which accidentally carbonised thousands of rice grains.

Retrospect

In November 2011, the Personal Histories Project under the direction of Pamela Jane Smith arranged a session on Eric Higgs and the Bone Room. This provided an opportunity for the many young archaeologists in the audience to learn at first hand, the excitement and feeling of exploring new generated by Eric's ideas and fieldwork. Tony Legge was a prominent contributor and reflecting on his own distinguished contribution to economic prehistory always causes me to reflect on the early days, and my first encounter with both him, and the mark 1 dustbin/flotation machine.

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How the pig parts got from Warrago to Web

James F. O'Connell

Tony Legge and I met just three times. Twice in Cambridge: once at an early 1980s seminar where he, Todd Whitelaw and Peter Rowley-Conwy put the wind up the gaggle of post-processualists present before leading several of us off to *The Eagle* for drinks (the PPs declined to accompany us – ‘poor show,’ I thought, since the first shout should have been theirs); the other, in 2007, centered on a quiet meal and talk about topics of mutual interest, including the occasion on which Legge and I first encountered one another.

At the time of that meeting, the austral winter of 1977, I was a Research Fellow in Jack Golson’s Department of Prehistory in the Research School of Pacific Studies, Australian National University, Canberra. It was an exciting period in regional archaeology, and Golson’s department, with its unusual mix of archaeologists and ethnographers, was in many ways at the center of it – some members pushing the earliest dates for Australian colonization back toward 40,000 BP and beyond, others exploring the origins of New Guinea trade systems and agriculture, still others living for many months in remote Aboriginal communities, trying to connect observed behavior with its archaeological consequences in the enterprise called ethnoarchaeology. There was a strong materialist tilt to all of this, not surprising since many of the players were closely linked with the Cambridge school of economic prehistory. Even I – one of the few North Americans in the group – had a Cambridge connection: my teachers at Berkeley had included Desmond Clark, Glynn Isaac and Robert Rodden, all Cambridge-educated.

Legge, a prominent product of the Cambridge school, had landed in Canberra for about a month, the main purpose being to demonstrate and discuss the use of a ‘froth flotation’ machine, a device developed by members of Eric Higgs’s Cambridge research group to retrieve small plant parts from archaeological deposits, an important component of their work on the origins of Near Eastern agriculture. I don’t know whether the device was ever employed in Australian research, but Legge’s demonstration was impressive enough, and many of us liked the idea behind it, even if in the end we couldn’t see using it ourselves.

In any case, with all the talk about Near Eastern agriculture and the importance of developing modern comparative collections essential to research on plant and especially animal domestication, the possibility of obtaining some feral pig skulls somehow came up. A few phone calls were made and a trip was organized out to Ford’s Bridge, a small community near the Warrego River, about 800 km

north-west of Canberra. It was a ten-hour drive in the Land Cruiser, half of it on the nearly dead-straight run along the Mitchell Highway and then on the Dowling Track, from Narromine past Bourke to Ford's Bridge. In the course of that very monotonous drive, Legge and I found that we had many interests in common apart from the obvious academic overlap. We both had military experience (Legge's far more extensive than mine), a common love of arid lands archaeology, and a keen interest in firearms and hunting.

We ultimately made our way to Lower Lila Station, a sheep run straddling the Warrego floodplain, north-east of Ford's Bridge. The station operator seemed pleased to see us: pigs were ravaging his flocks, especially in lambing season, and even a small reduction in their numbers clearly struck him as a good idea. He noted that pigs were dangerous to people on foot and offered in support a few nasty anecdotes about hostile human-pig interactions. His admonition echoed and elaborated on a remark we'd heard the night before in the Ford's Bridge pub: 'Don't shoot at a pig unless you're close to a tree you can climb!'



Fig. 5.1. Tony Legge with Remington .222 and the first three pigs taken on a hunting trip near Ford's Bridge, NSW.

Suitably warned, off we went to a suggested spot, where we left the truck and set off on foot. Legge was carrying a scope-sighted, bolt action Remington .222, excellent for long shots in open country on relatively small game, but not the best option in this situation. The action was a bit slow, the scope tricky to aim in close cover, and the punch less than desirable against potentially problematic pigs. In principle, I had the better piece: a Model 94 lever action Winchester .30–30, a short saddle gun with open sights, perfect for work in close cover and with more than enough knock-down power for the

task at hand.

As I recall, we weren't more than a few minutes into the walk when we had the first, most dramatic encounter of the day. Half a dozen pigs burst from cover running right to left at a distance of about 50 m. Legge fired three shots in seconds while I managed just one before the survivors were out of sight. We'd dropped four targets dead, but the thing that got me at the time was Legge's speed of reaction and accuracy, especially with an unfamiliar weapon. PETA forgive me, but it was the highlight of the day.

By late afternoon, we'd taken a total of nine pigs, with no need for tree-climbing. The question was what to do next. Legge suggested we simply cut off the heads (he was mainly interested in comparative data on teeth), wrap them in plastic sheets and a tarpaulin, tie the package to the truck's bull bar, and go home. Which we did. The heads were buried on the Rhys Jones-Betty Meehan property outside Canberra, retrieved years later, properly cleaned, transported to England, and ultimately posted on the Web, where they can be visited and studied today (http://www2.arch.cam.ac.uk/repository/legge2009_01.pdf). *[this paper is reproduced as chapter 7 in this volume]*.

Looking back, this still strikes me as a great experience, one that reinforces my view of Legge as (in the overworked but in this case completely accurate phrase) a man's man: smart, direct, a great raconteur, totally charming in a wide range of settings, and (for me, not least of all) an amazing shot. What more could one want in a companion on a pig-shooting trip 'back o' Bourke'?

Tony Legge and the Blick Mead Project

David Jacques

The recently discovered Mesolithic site at Blick Mead, about 2 km from Stonehenge and close to the town of Amesbury, must have been one of the last small projects Tony Legge encouraged and worked on. He continued to give advice and time to it until early in the New Year 2013.

At the time of Tony's first involvement with Blick Mead, in the spring of 2012, the project had been running on between £500–£1000 per year for 6 years, which just about paid for one long weekend dig per annum. Our excavations, partly out of necessity, have allowed people of talent, whatever their age or background, to self organise, and as it happened Tony's grandson Tom had been part of a team that excavated a large cache of large animal bones in April 2012. We were not aware of Tom's relationship with Tony, but on the Saturday night Tom said who Tony was and that he was sure that he would be interested in the bones. I was only back at home for a day when Tony wrote and offered a meeting.

Within a few a minutes of being with him I was struck by what seemed to be Tony's unstoppable vitality – he was keenly enthusiastic about what we had found, and very practical about how we should manage things on site from there on. He took our meagre funding and 'no names' team in his stride and gave advice on how best to work in the oozy springhead we were dealing with. In our second meeting he talked about how he could best support the research effort. First, he offered to analyse all the bones we had found for free and write up the results for publication. Then he gently, but firmly suggested we use a particular design of water sieve to recover the most from the material in the spring, and then – knowing that we could not afford to buy such a sieve, gave me his own design plans so that we could make them ourselves. He also said he would come to the site and meet anyone who was sceptical about its archaeological worth.

One area where we have always been rich as a project is in the local support of the Amesbury community. I sent Tony's designs for our sieves to Amesbury resident Councillor Fred Westmoreland, who had been ably co-ordinating the town council's logistical support for our project since 2009. Fred quickly mobilised a number of Amesbury residents and businesses to support the making of 'Tony's' sieves and by the autumn of 2012 we were presented with three of them, made of stout oak, on site. These were donated gratis by Fred and Amesbury and serve today as an enduring symbol of the connection between the project, the town and Tony.

Thanks to this bridge established between town and gown, our next long weekend dig in

October 2012 was able to really maximise the retrieval of artefacts. The sieves worked brilliantly in the tough conditions of the site and have continued to do so. At the time of writing we have found over 32,000 artefacts from Mesolithic contexts, in an area of just 16 m square. Over 1000 of these objects are from animal materials and from these eleven radio carbon dates have been taken that show that people were visiting the site and feasting there for nearly three millennia from c. 7,500 to 4700 BC. This is a unique sequence for the British Isles. It would not have been fully discovered without 'Tony's sieves' and his advice.

Tony and I continued to meet over the course of 2012. Each time he was open, practical, drily humorous and completely unbothered about reputation and standing – ideas, data and potential were what he was interested in. Like the best professors, he had great teaching skills, an ability to put you at your ease so that you were best able to give the best account of your ideas. When his analysis of the bones from the site revealed that we had found an unusually large percentage of aurochs in the assemblage (61%) he was particularly keen to discuss the significance of that and to explore any parallels. He liked it that some of our finds and the research were beginning to impact on the research agendas for the Stonehenge landscape.

In December 2012 Tony said he was struggling with his eyesight, but he still found the energy to nominate me for Cambridge University's Field Archaeologist in Residence post so that the project would benefit from the university's resources. His close interest in what we doing continued near to the his death when he asked his daughter Karen, Tom's mother, to try and make sure that Peter Rowley-Conwy would get a chance to meet project team members at his funeral.

My short time of knowing Tony Legge probably charts a pattern of behaviour in him which others for a longer period would recognise. He was incredibly generous with his time. He was warm, full of energy and had the great teacher's trick of wearing a massive accumulation of knowledge lightly for other's benefit. You felt 'at home' with him. He made you feel at ease – always a thoughtful and generous quality. Tony transformed our project at Blick Mead in all respects because of all these characteristics. Our self-belief in what we were trying to do was greatly increased because of him. The project's reputation and standing was underscored by his approval. Our finds retrieval was greatly improved because of his ideas and care. Tony's presence lives on at the site, as we are sure it does in many others, because of his actions, thoughts and essential humanity.

Part II

Zooarchaeological method and theory

Bone measurements and body weights from some Australian feral pigs

A. J. Legge[†]

Introduction

A small sample of pig skulls and part skeletons from Australian feral pigs is described below. The specimens were collected in the initial stage of a research project intended to look at the process of animal domestication when going in reverse, as with the feral pigs of Australia. However, this project was never completed. The data below is offered in the hope that it is sufficient to be useful to those with an interest in pig osteology, and perhaps to encourage further work. [*The story of how these pigs were acquired is described by Jim O'Connell in chapter 5 of this volume*].

The feral pigs of Australia were introduced there as domestic animals during the nineteenth century, originating largely from British stock, possibly with some local admixture of breeds from South-east Asia. In earlier times, outback stations raised their own pigs on a free ranging system in which the animals were free to roam, but returned to their owners each night. The same system is operated now as a traditional right in the New Forest in England and this was a common husbandry system in earlier times, in both urban and rural environments. In 1842 the writer Charles Dickens saw free-ranging pigs in New York, swaggering home along Broadway (see his *American Notes*; many editions). Not that unusual – he would have seen the same in Cambridge, England, where the author's ancestors would have raised their pigs in New Square, as did all of the households there, to the despair of the local medical authorities. In Australia, the wide-ranging outback pigs gradually learned to live away from their human owners, to become the feral 'razorbacks' – now a virtual plague.

The specimens were collected during a brief trip to north-west New South Wales in the company of Professor James O'Connell, now of the University of Utah, USA. The pigs were collected at the Lower Lila Station, which lies north of the town of Bourke (approximately 30° 15'N, 145° 56'E). The pigs lived along the Warrego River, a tributary of the River Darling. The region is arid, with 300–500 mm rainfall per annum, so that the Warrego is an ephemeral river, though capable of extensive flooding after heavy rainfall. The river was carrying water at the time of our visit in August 1977, but with little flow. The river banks had areas of thick cover, of the type generally known as 'mallee scrub', though this in itself is of variable nature. Sizeable swamp areas were intensively used by the pigs. Their diet thus consisted of a good deal of water vegetation, plus anything edible found by rooting up the drier ground. Carrion of all sorts was much favoured in the diet, and live sheep too if these could be caught. Recent Australian government evidence suggests that the feral pig population

now might be 20–40 million, spread over all of Australia except for the dry centre. The pig population is thus something of an environmental disaster as their depredations cause very significant harm to the native flora and fauna.

The limited processing facilities that we had available at the time meant that only skulls and some limb bones were taken in this first sample. The specimens were buried near to Canberra for cleaning, and the bones were later kindly excavated by Betty Meehan, Rhys Jones and Matthew Spriggs. The project was much encouraged and assisted by the late Rhys Jones. The work was done during the tenure of a fellowship by the author at the Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra, Australia. This institution and its staff of that time are gratefully, if belatedly, acknowledged for their support and the provision of generous facilities. The holders of the Lower Lila Station were kind with permission to range over their land.

Table 7.1. Cranial measurements of the animals discussed

<i>skull measurement</i>	<i>LL 1</i>	<i>LL 2</i>	<i>LL 4</i>	<i>LL 7</i>	<i>LL 8</i>	<i>LL 9</i>	<i>Spain</i>	<i>India</i>
1a	287.0	210.0	246.5	247.0	264.0	301.0	310.0	396.0
1	271.0	211.0	244.0	245.0	282.0	311.0	304.0	321.0
2	266.0	NP	2450	234.0	262.0	285.0	274.0	334.0
3	257.0	NP	235.0	243.0	3253.0	275.0	262.0	320.0
8	129.0	NP	114.0	114.0	121.0	122.0	124.0	155.0
9	110.0	100.0	112.0	110.0	126.0	130.0	145.0	192.0
10	162.0	113.0	142.0	140.5	152.0	170.0	158.0	204.0
11	91.0	79.01	83.1	90.0	105.0	106.0	113.0	145.0
12	180.0	135.0	161.5	162.0	175.0	193.0	195.0	251.0
21	230.9	32.4	37.0	37.6	37.8	42.8	51.6	52.0§
22	20.2	22.7	26.7	25.9	25.0	29.7	24.5	27.0#
25	107.3	102.30	102.30	104.0	101.6	111.6	NP	126.6
27	97.6	NP	97.1	97.8	97.0	101.0	NP	115.3
28	56.9	NP	56.3	61.1	57.0	60.8	NP	78.0
29	40.0	NP	40.4	38.1	39.1	41.1	46.4	44.2
30	29.1	NP	27.8	30.3	29.6	30.2	NP	43.5
31	18.5	NP	17.7	18.6	19.0	18.0	NP	22.8
40	24.5	24.5	26.5	28.2	24.1	28.5	27.2	46.5
43	139.5	105.0	121.5	127.0	147.0	142.3	117.0	152.8
44	66.3	52.4*	62.4	62.9	68.6	64.0	59.0*	75.6

* at M²; § left side; # estimated – suture eliminated; measurements follow the definitions of von den Driesch (1976).

Table 7.2. Mandibular measurements of the animals discussed

<i>mandible measurement</i>	<i>LL 1</i>	<i>LL 2</i>	<i>LL 4</i>	<i>LL 7</i>	<i>LL 8</i>	<i>LL 9</i>	<i>Spain</i>	<i>India</i>
1	217.0	167.0	199.0	205.5	230.0	243.0	213.0	288.0
2	229.0	176.0	206.0	215.0	235.50	247.0	231.0	302.0
4	155.0	NP0	144.0	147.5	155.0	166.0	NP	195.0
5	159.0	125.0	150.0	155.0	164.0	170.0	158.0#	206.0
6	113.9	NP	111.0	102.6	117.6	124.6	NP	144.0
7a	91.5	NP	95.0	95.0	93.5	114.5	NP	115.3
8	60.8	NP	64.5	64.5	63.4	63.3	NP	79.5
9a	42.6	30.0	28.0	31.4	30.0	31.4	40.5#	34.8
10 (M3 L)	31.8	nye	34.5	34.5	35.5	35.4	n/a	44.9
10 (M3 B)	15.5	nye	14.2	14.8	15.0	15.3	n/a	18.0
16a	42.5	NP	40.0	45.8	53.0	53.0	NP	53.7
16b	40.5	27.2	Bk	37.2	44.8	44.5	34.6	49.3
16c	40.0	25.6	32.3	39.1	46.6	45.7	37.1	50.0

estimated; nye = not yet erupted; measurements follow the definitions of von den Driesch (1976).

Table 7.3. Tooth wear states are recorded as above

<i>No.</i>	<i>Age</i>	<i>Sex</i>	<i>P2</i>	<i>P3</i>	<i>P4</i>	<i>M1</i>	<i>M2</i>	<i>M3</i>	<i>MWS</i>
BIAA 29	19–23 months	F	a	b	b	d	b	Cr	17
SP352	31–35 months	F	b	d	e	h	e	b+	30
SP344	Adult	F	e	e+	f	h	g	d	34
SP350	Adult	M	e	f	f	L	j	f	41*
Spain	Subadult	F	Er	a	a	b	a	Cr	13
India	Adult	M	b	d	e	j	f	d	34
LL1	Adult	F	e	f	m	m	k	d	39
LL2	Juv	M	Er	So	a	h+	c	Cr	22
LL4	Adult	F	d	d	f	n	j	d	41
LL7	Adult	F	c	e	f	n	j	d	40
LL8	Adult	M	b	d	f	n	j	d+	41
LL9	Adult	M	d	f	f	n	k	d+	42

Data for specimens designated ‘BIAA’ and ‘SP’ are from Bull and Payne (1982, figs 2–5). Er=tooth in eruption So=empty socket, post mortem tooth loss. Cr=crypt formation. For Grant’s stage ‘L’ the upper case letter is used to avoid confusion. *the values for stages L and k appear to be reversed in Grant (1982, table 1). The values taken here are the *opposite* to those as quoted: k=15, L=16.

If anyone seeks to continue with such studies, allow me to repeat some sound advice that was given to me in a bar at Ford’s Bridge, which is back of Bourke: ‘Don’t shoot at a pig unless you are near a tree that you can climb.’

The data

The cranial measurements are given in Table 7.1, those of mandibles in Table 7.2. Limb bone measurements are given separately below, where available. All measurements are based on the system of von den Driesch (1976, 38–41 figs 12 a–f [cranial measurements], 58–59 figs 21a–b [mandibular measurements]). Measurements marked ‘NP’ could not be taken due to incomplete development or damage to the bone.

Mandible length and body weight shows a consistent relationship, at least in this small sample

(Fig. 7.1 top). Further data from Gallo Orsi *et al.* (1992) suggest that the relationship between jaw length and body weight is somewhat different in males and females as these become fully adult. Reliance is often placed upon the length of M3 as an indicator of gross body size in adult pigs. This small sample suggests that this relationship is at best weak (Fig. 7.1 bottom), and that it should be explored further. The relationship between the depth of the mandible (measurement 16a of von den Driesch 1976) and body weight is moderately good (Fig. 7.2 top), indicating that this measurement would provide useful data from samples of fragmentary mandibles. However, the measurement of the least parietal width of the skull evidently has a very weak relationship with body weight (Fig. 7.2 bottom).

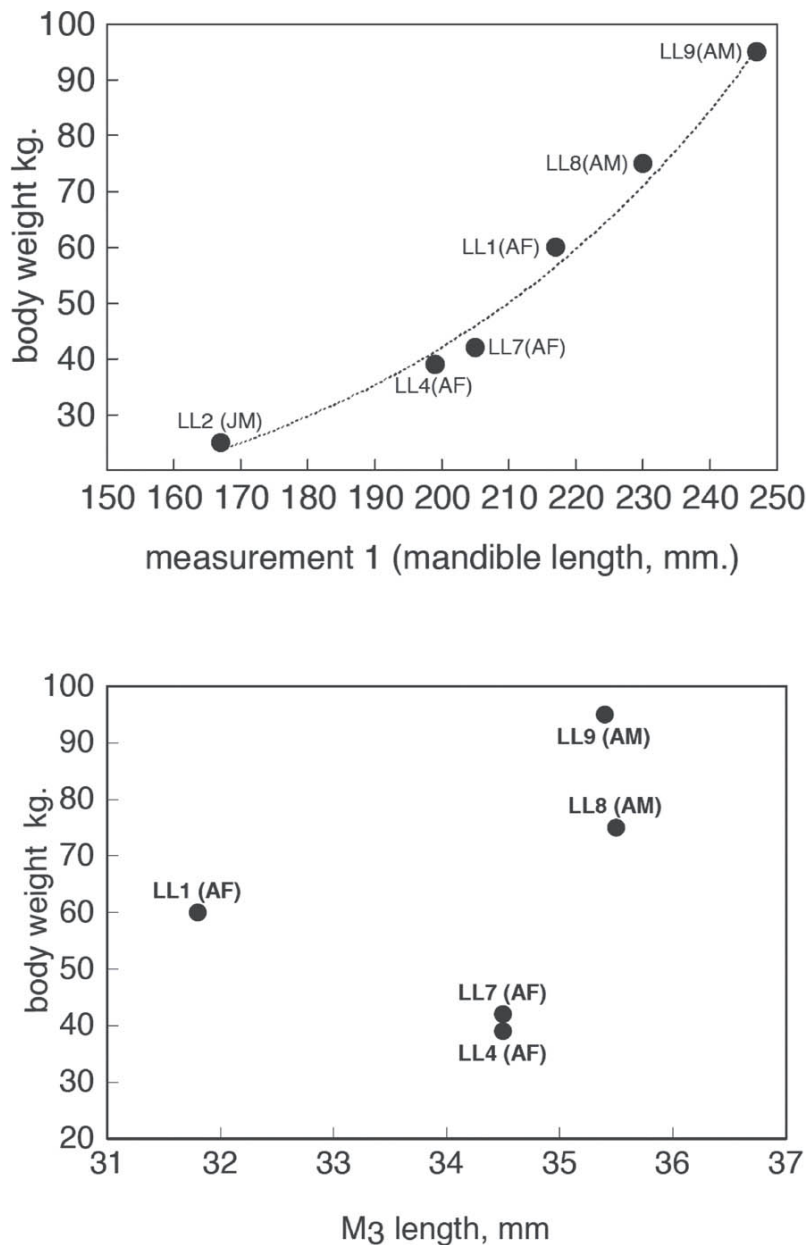


Fig. 7.1. Body weight of the Lower Lila specimens, compared to mandible length (top) length of lower M3 (bottom). A = adult, J = juvenile, M = male, F = female.

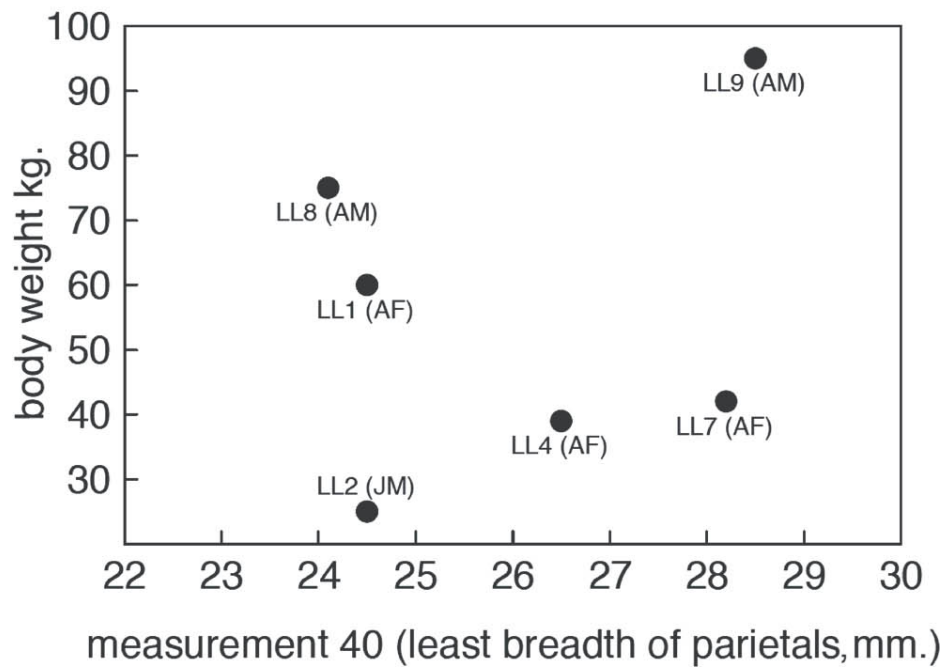
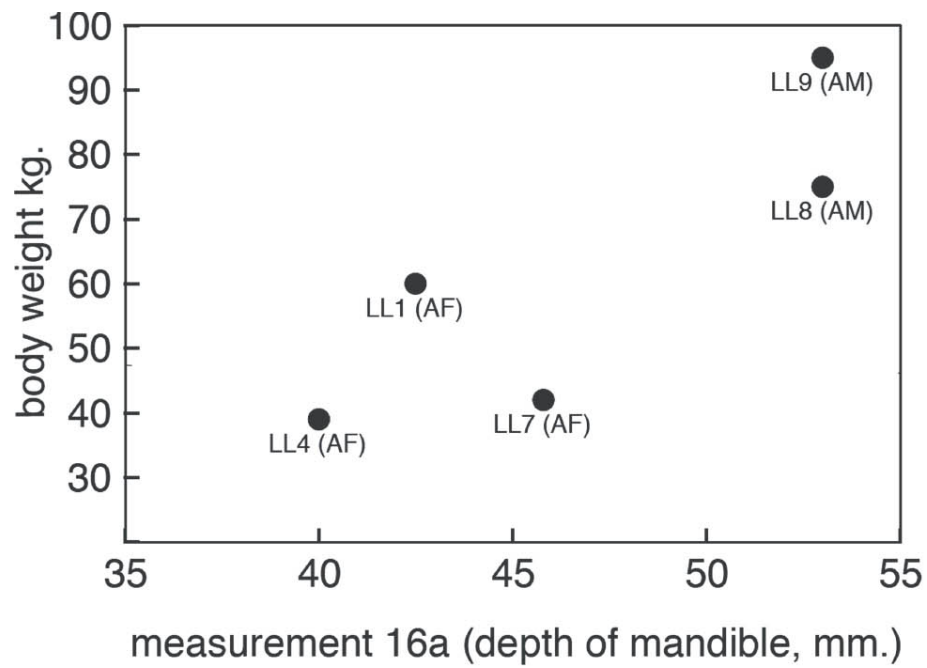


Fig. 7.2. Body weight of the Lower Lila specimens, compared to depth of mandible (measurement 16a) (top), and least parietal width (measurement 40) (bottom).

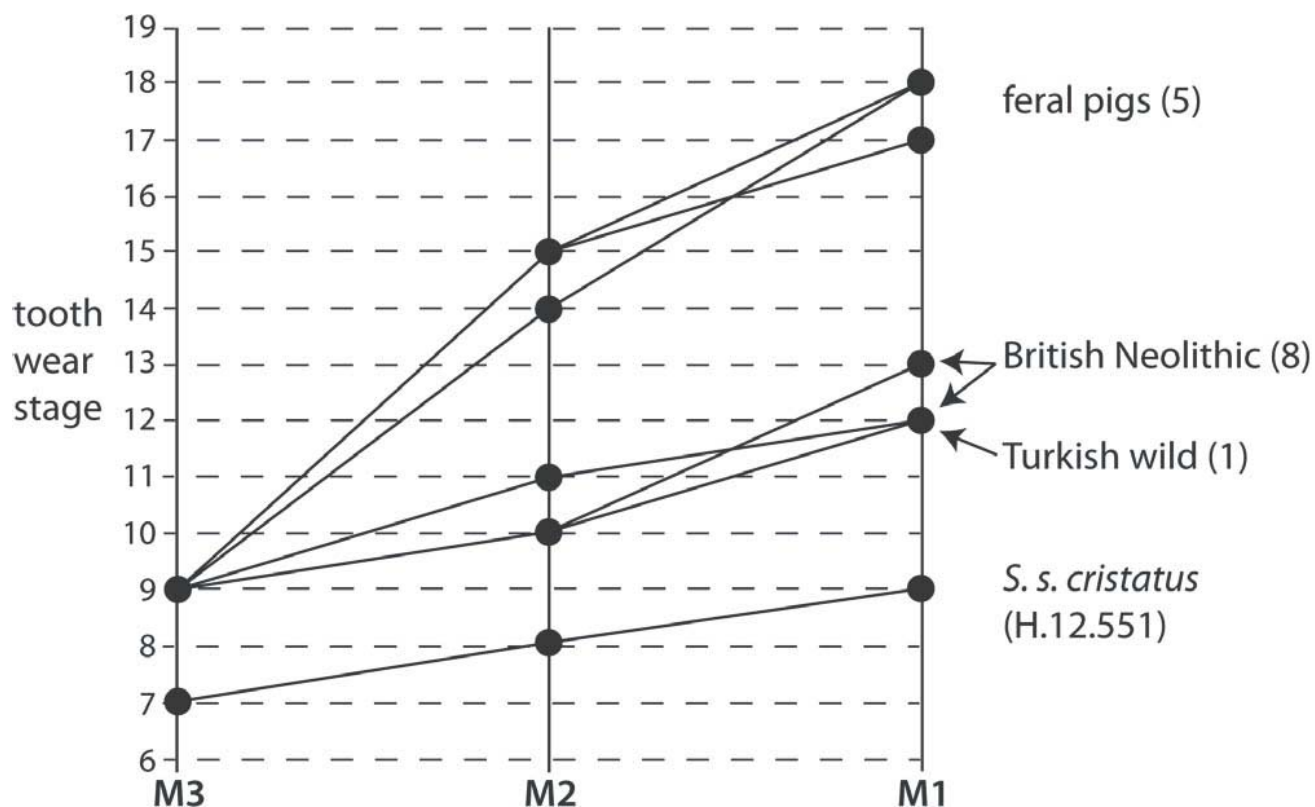


Fig. 7.3. Relative tooth wear in various populations of pigs.

The alphabetic pig tooth wear stages listed in Table 7.3 are taken from Grant's (1982) illustrations of successive wear states for the mandibular cheek teeth, P4 to M3. In the tabulations below, the wear states are also given for the upper teeth and the lower P2 and P3. These wear states are not illustrated by Grant, but are the best approximations based upon the wear states of lower P4 to M3. The '+' symbol after a Grant letter code means that the wear state is beyond that illustrated by Grant (1982, 94 fig. 3), but has *not* reached the next stage as illustrated. Other codes used below: Cr = crypt of tooth forming; V = tooth visible in crypt but not erupted; Er = tooth erupting through bone; So = empty socket, tooth loss postmortem.

The Australian feral pigs show a very high rate of wear, doubtless associated with the sandy terrain in which these animals lived. British and modern Turkish wild boar (Bull and Payne 1982) show lower rates of wear, and *Sus scrofa cristatus* has the lowest wear rate of all, presumably reflecting a soft diet, free from abrasive particles. Figure 7.3 plots specimens with early wear on M3 (Grant 1982, 94, fig. 3, stages b-d, TWS 7-9).

Descriptions and measurements

The right side is measured unless stated otherwise.

Pig LL1

Adult female (Figs 7.4 and 7.5). Cranium and right front and hind limbs taken. Deadweight 60 kg. Body hair black all over, well developed on shoulders, front limbs and dorsal.

Mandible: the mandibular teeth are in full wear, and the M₃ is fully erupted and worn on all

cusps. Both M_1 are heavily worn, the left side having the pulp cavity exposed on both cusps. The second cusps of right and left M_2 have marked oblique wear, the tooth being worn lower at the lingual margin. However, the second cusps of right and left M_2 do not show a peak of unworn enamel at this point when the mandible is articulated with the skull. The other older pigs in this collection (LL Pig 8 and LL Pig 9) do not show this oblique wear, although the M_1 and M_2 are heavily worn.

Mandibular tooth wear (Grant numeric stages):

$P_2=d$	$P_3=e$	$P_4=f$	$M_1=m^*$	$M_2=k\#$	$M_3=d$	MWS
			TWS=17	TWS=16	TWS=9	42

* pulp cavity exposed on left M_1 ;

wear oblique on cusp 2 of M_2 .

Maxilla: development and wear of teeth accords with the mandible. M^3 is fully erupted and has wear on the posterior cusp.

Bone measurements (mm, right side)

Scapula: fused. HS=163.0 GLP=33.6 BG=22.0 SLC=22.6

Humerus: fusing proximal, fused distal.

GL=166.0 GLC=150.0 DP=53.7 Bp=45.3 SD=14.4 Bd=38.7 BT=32.6 HT=28.1E
(estimated to allow for some degree of exostosis on medial margin of trochlea; see remark on radius below)

Radius: fused proximal, late fusing distal (fusion line partly closed). The proximal radius has an exostosis on its medial margin which prevents measurement.

GL=127.0 Bp=NP SD=18.5 Bd=31.7 BFD=26.3

Ulna: fused proximal. Very late fusion distal (trace of fusion line).

GL=173.0 LO=52.2 DPA=36.7 SDO=24.8

Femur: fused proximal, very late fusing distal (anterior line only visible).

GL=186.5 GLC=181.0 Bp=48.4 DC=21.9 SD=17.4 BD=42.1

Tibia: late fusing proximal, fused distal.

GL=169.0 SD=18.4 Bd=27.5 Dd=24.5
(maximum measurement at rt-angles to Bd)

Calcaneum: fused. GL=68.8

Astragalus: fused. GL=37.9 GLm=34.3 BD=22.8

Metacarpal III: GL=65.3 Bp=17.1 B=12.5 Bd=16.0

Metacarpal IV: GL=66.4 Bp=14.1 B=11.1 Bd=16.3

Metatarsal III: GL=70.0 Bp=14.0 B=11.0 Bd=15.4

Metatarsal IV: GL=74.6 Bp=15.2 B=12.8 Bd=16.3

Phalanx 1 (front lateral): Bp=15.2 GL=30.4 Bd=14.5

Phalanx 1 (front medial): Bp=15.3 GL=30.0 Bd=14.8

Phalanx 1 (hind lateral): Bp=15.5 GL=32.1 Bd=14.2

Phalanx 1 (hind medial): lost

Phalanx 2 (front lateral): Bp=14.9 GL=21.8 Bd=13.5

Phalanx 2 (front medial): Bp=15.5 GL=20.3 Bd=13.8

Phalanx 2 (hind lateral): Bp=15.1 GL=20.1 Bd=14.1

Phalanx 2 (hind medial): Bp=14.7 GL=21.6 Bd=12.5

Phalanx 3: GL=27.5, 27.5, 26.4, 26.9

Atlas vertebra: fused. GL=40.4 GB=73.4 BFCr=50.4

Axis vertebra: fused. BFCr=40.5

Pig LL2

Juvenile male. Cranium, right front and hind legs taken. Deadweight 25 kg. Body hair sandy brown, black dorsal and ventral. Pronounced dorsal hair ridge.

Mandible: the M^3 is not erupted, this tooth showing early crypt formation. The P_2 was lost post

mortem in both right and left mandibles. Central incisors erupted, medial and lateral incisors erupting but not yet through bone.

Mandibular tooth wear (Grant numeric stages):

$P_2=Er$	$P_3=so$	$P_4=a$	$M_1=h+$	$M_2=c$	$M_3=Cr$	MWS
			TWS=13	TWS=8	TWS=1	22

Maxilla: tooth development and wear accords with the mandible. M^3 unerupted, crypt in formation, enamel crown in formation. Both P^3 were lost post mortem.

Humerus, radius, ulna, femur, tibia: all unfused proximal and distal.

Metacarpal and metatarsal: unfused distal. Phalanx 1 and 2: unfused proximal.

Pig LL4

Adult female (Fig. 7.6). Cranium only taken. Body hair all black, marked dorsal hair ridge. Body length tip of snout to root of tail=104 cm. Deadweight=39 kg.

Mandible: the M_3 is fully erupted, but with no wear on the posterior enamel pillar.

Mandibular tooth wear (Grant numeric stages):

$P_2=d$	$P_3=d$	$P_4=f$	$M_1=n$	$M_2=j$	$M_3=d$	MWS
			TWS=18	TWS=14	TWS=9	41

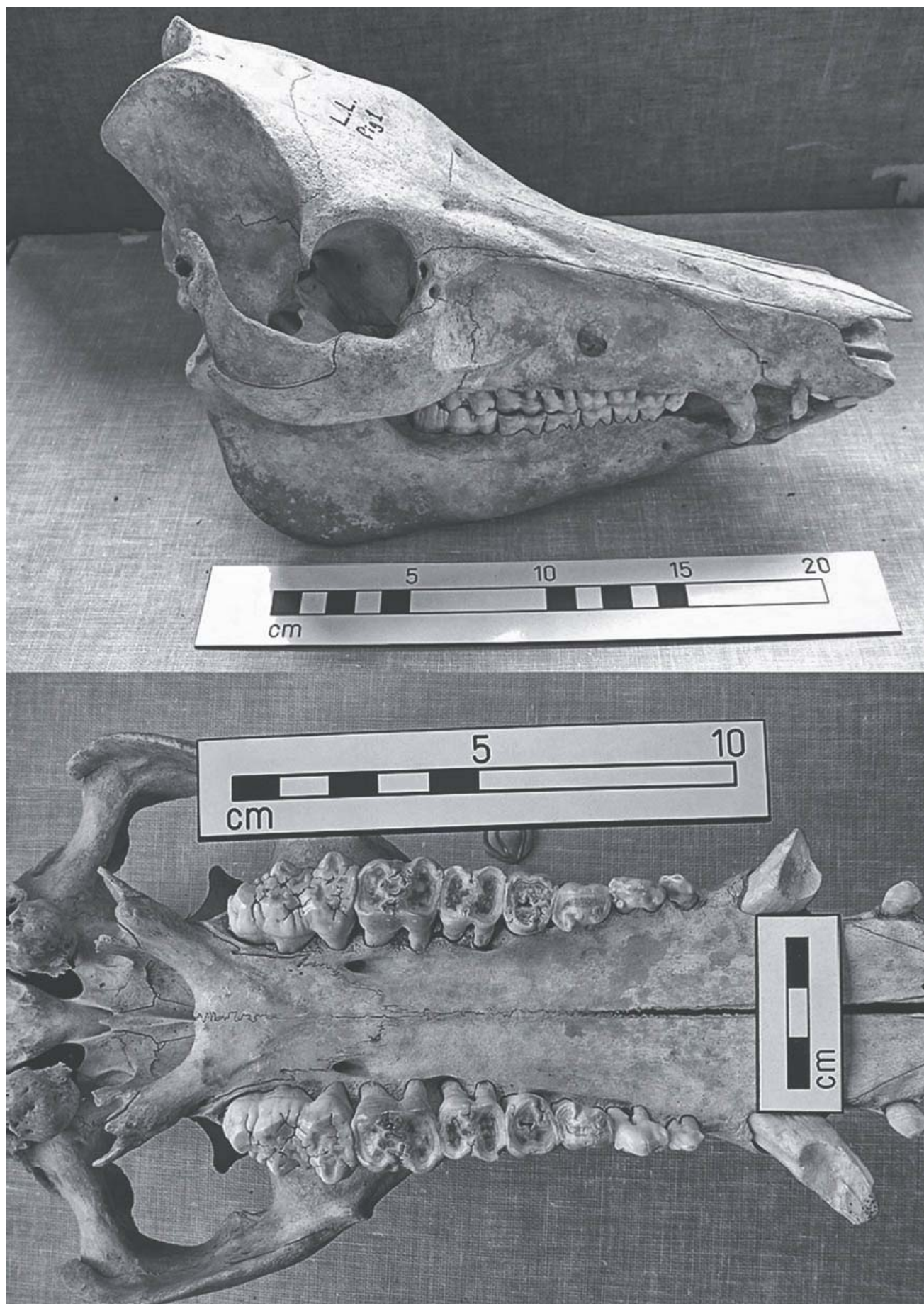


Fig. 7.4. LL pig 1, skull and maxilla.

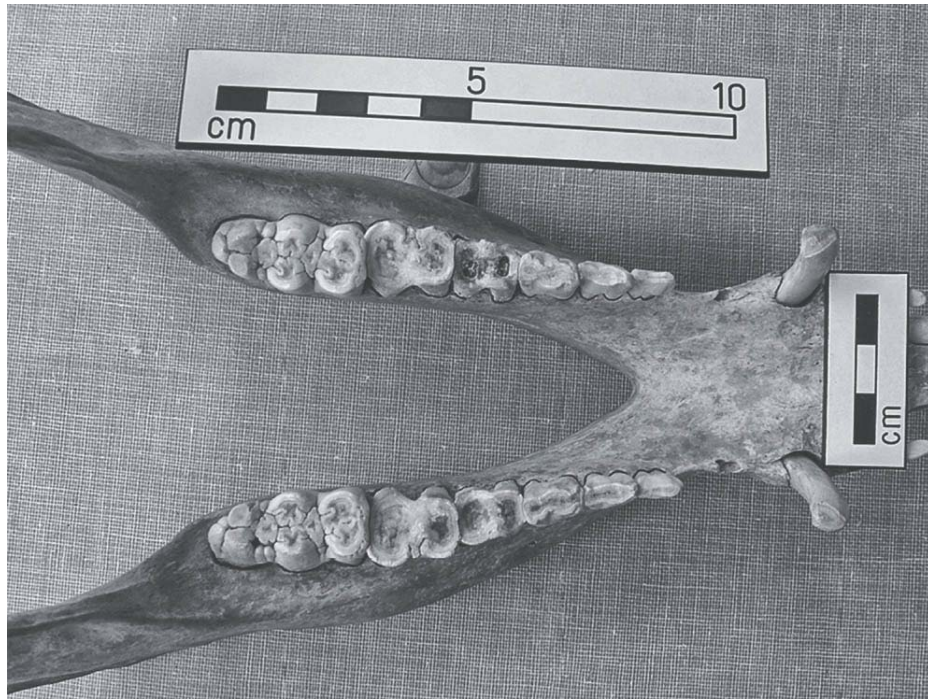


Fig. 7.5. LL pig 1, mandible.

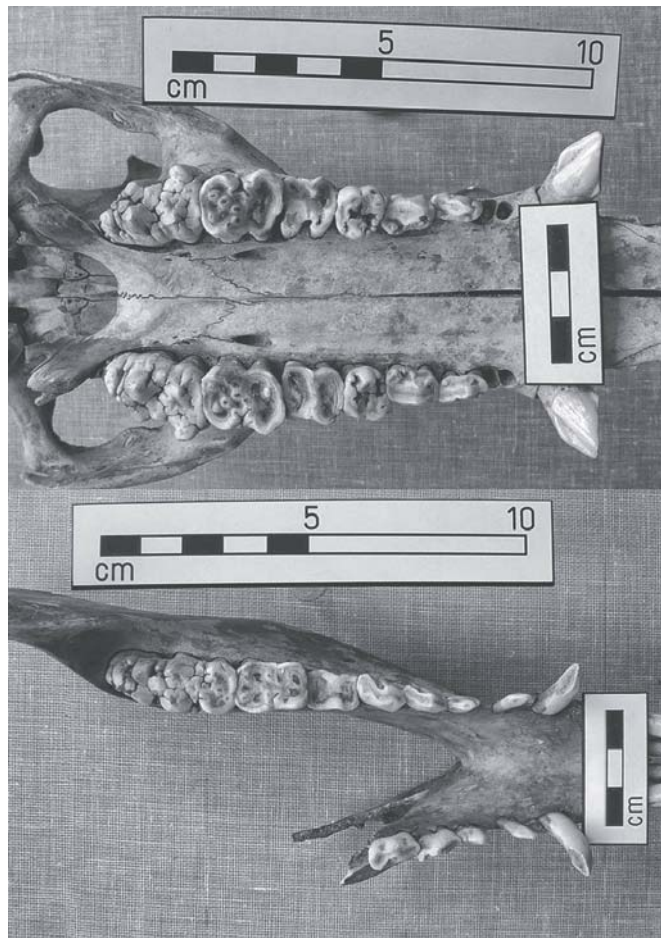


Fig. 7.6. LL pig 4.

Maxilla: tooth wear accords with the mandible, M^3 fully erupted, but with no wear on the posterior pillar. The dentition is notable for the extreme wear on M_1 and heavy wear on M_2 , occurring soon after the full eruption of M_3 .

Pig LL7

Young adult female (Fig. 7.7). Cranium only taken. Body hair all black, marked dorsal hair. Body length tip of snout to root of tail = 108 cm. Deadweight = 42 kg.

Mandible: M_3 is not fully erupted, with no wear on the three posterior pillars.

Mandibular tooth wear (Grant numeric stages):

$P_2=c$	$P_3=e$	$P_4=f$	$M_1=n$	$M_2=j$	$M_3=c$	<i>MWS</i>
			TWS=18	TWS=14	TWS=9	40

Maxilla: tooth wear is in accord with the mandible, M^3 not fully erupted, with no wear on the posterior part of the tooth. The dentition is notable for the extreme wear on the M^1 even before the full eruption of the M^3 .

Pig LL8

Adult male (Figs 7.8 and 7.9). Cranium only taken. Body hair all black, marked hair growth dorsal ridge and on shoulders. Skin thickness on shoulders ± 1 cm. Body length tip of snout to root of tail = 140 cm. Deadweight = 75 kg.

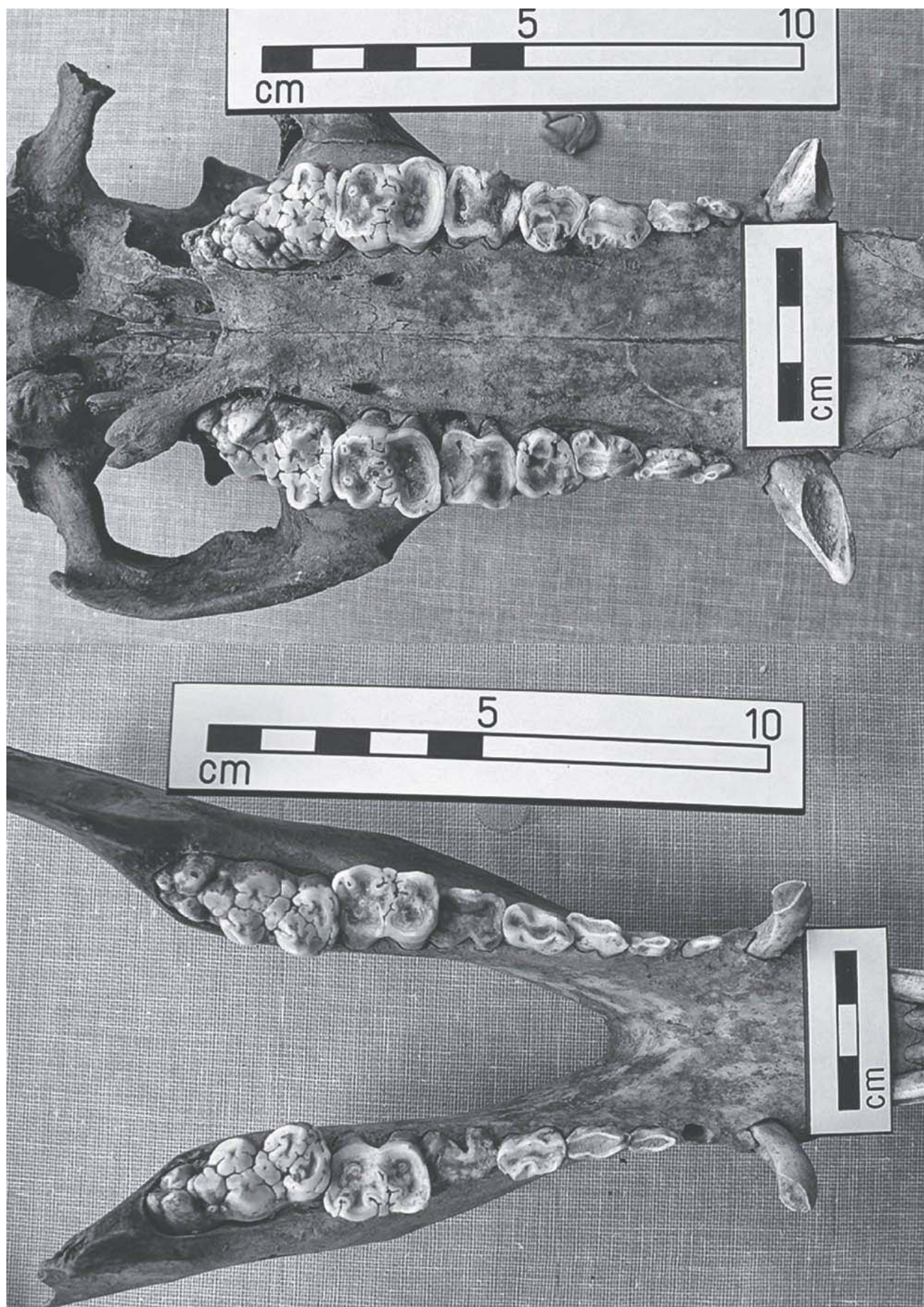


Fig. 7.7. LL pig 7.

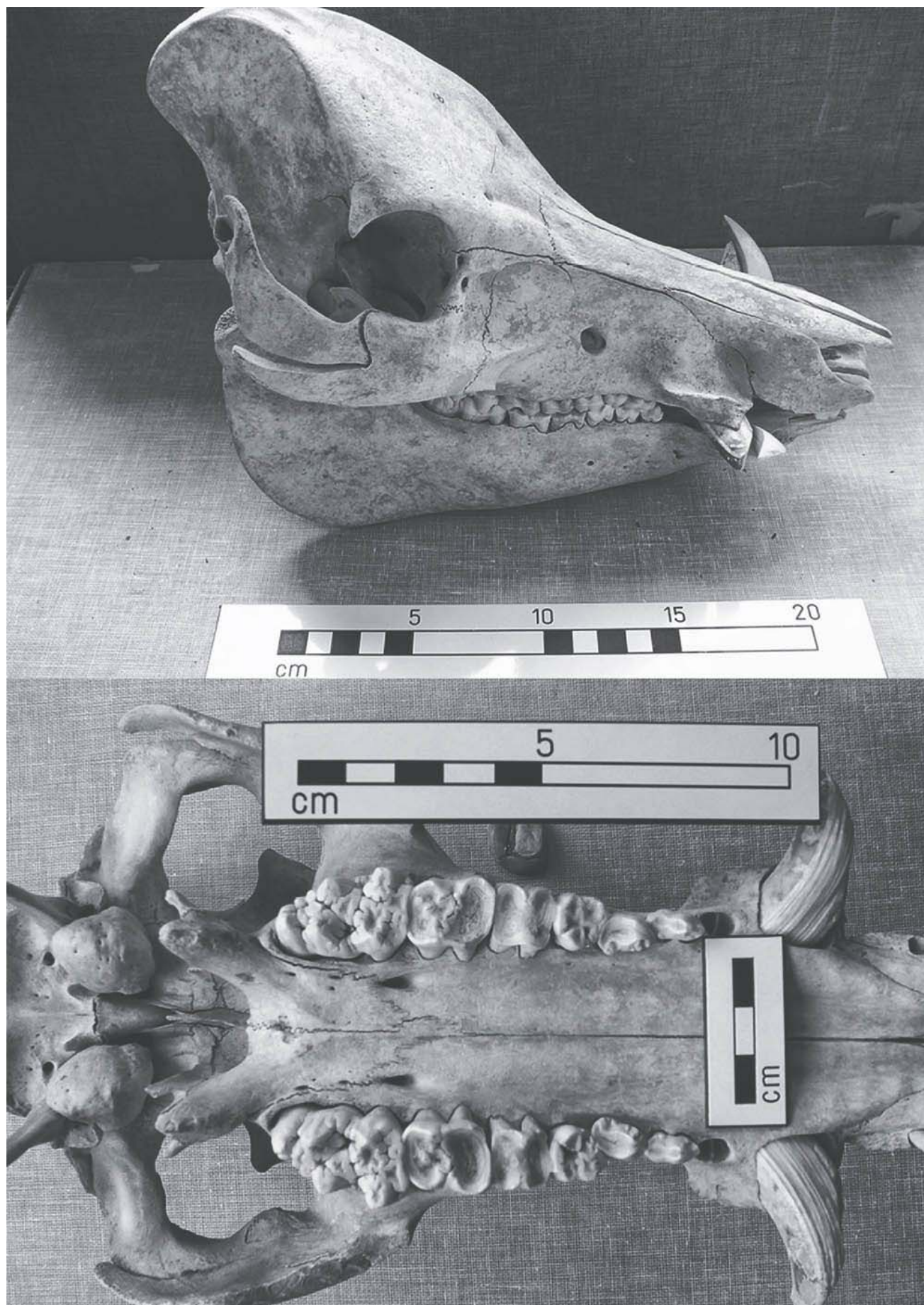


Fig. 7.8. LL pig 8, skull and maxilla.



Fig. 7.9. LL pig 8, mandible

Mandible: the dentition is fully developed, with M_3 fully erupted, but without wear on the posterior pillar.

Mandibular tooth wear (Grant numeric stages):

$P_2=b$	$P_3=d$	$P_4=f$	$M_1=n$	$M_2=j$	$M_3=d+$	MWS
			TWS=18	TWS=14	TWS=9	41

Maxilla: tooth wear accords with the mandible. M^3 not quite fully erupted, with no wear on the posterior part of the tooth. The dentition is notable for the extreme wear on the M^1 .

Pig LL9

A very large male (Figs 7.10 and 7.11). Cranium, right front and hind legs taken. Body hair all black, marked dorsal hair growth. Recovered in swamp; very problematic to handle. Body weight exceeded maximum of weighing machine; deadweight estimated 90–100 kg.

Mandible: the dentition is fully developed, with the M_3 fully erupted, but without wear on the posterior pillar.

Mandibular tooth wear (Grant numeric stages):

$P_2=d$	$P_3=f$	$P_4=f$	$M_1=n$	$M_2=k$	$M_3=d+$	MWS
			TWS=18	TWS=16	TWS=9	43

Maxilla: tooth wear is in accord with the mandible. M^3 not quite fully erupted, with no wear on the posterior part of the tooth. The dentition is notable for the extreme wear on M^1 even before the full eruption of M^3 .

Bone measurements (right side)

Scapula (broken blade): GLP=37.6 BG=23.8

Humerus: unfused proximal, fused distal.

GL=167.4 (including unfused epiphysis) SD=16.2 BD=40.7 BT=29.7 HT=29.6 (for measurement HT, see Legge 1981, 102, 'T')

Radius: unfused distal.

GL=133.6 Bp=27.8 SD=18.3 Bd=32.7 (at fusion line) BFD=28.7

Ulna: early fusing proximal and distal.

GL=183.5 LO=53.1 SDO=27.9 DPA=38.1

Femur: broken, fusing distal.

Bd=42.9

Tibia: fusing proximal, fused distal. *Fibula*: unfused distal.

GL=178.4 BP=45.2 SD=19.0 Bd=29.8 Dd=26.5

Calcaneum: unfused process.

Astragalus: GLI=41.1 GLm=38.5 BD=24.9

Metacarpal III: fusing distal. GL=69.7 BP=18.0 B=13.9 Bd=15.5

Metacarpal IV: fusing distal. GL=70.0 BP=14.7 B=12.4 Bd=17.6* *at fusion line

Metatarsal III: fusing distal. GL=76.2 BP=15.2 B=12.5 Bd=16.0

Metatarsal IV: fusing distal. GL=79.2 BP=15.2 B=13.3 Bd=17.2* *at fusion line

Phalanges: all 1st and 2nd phalanges are fused proximal.

Phalanx 1 (front lateral): GL=31.5 Bp=16.8 Bd=15.7

Phalanx 1 (front medial): GL=31.3 Bp=16.5 Bd=15.2

Phalanx 1 (hind medial): GL=33.8 Bp=15.3 Bd=15.0

Phalanx 1 (hind lateral): GL=33.0 Bp=15.8 Bd=14.9

Atlas: fused. GB=86.5E GL=48.0 BFCr=58.2



Fig. 7.10. LL pig 9, skull and maxilla.



Fig. 7.11. LL pig 9, mandible.



Fig. 7.12. *Sus scrofa cristatus* lachrymal bone.

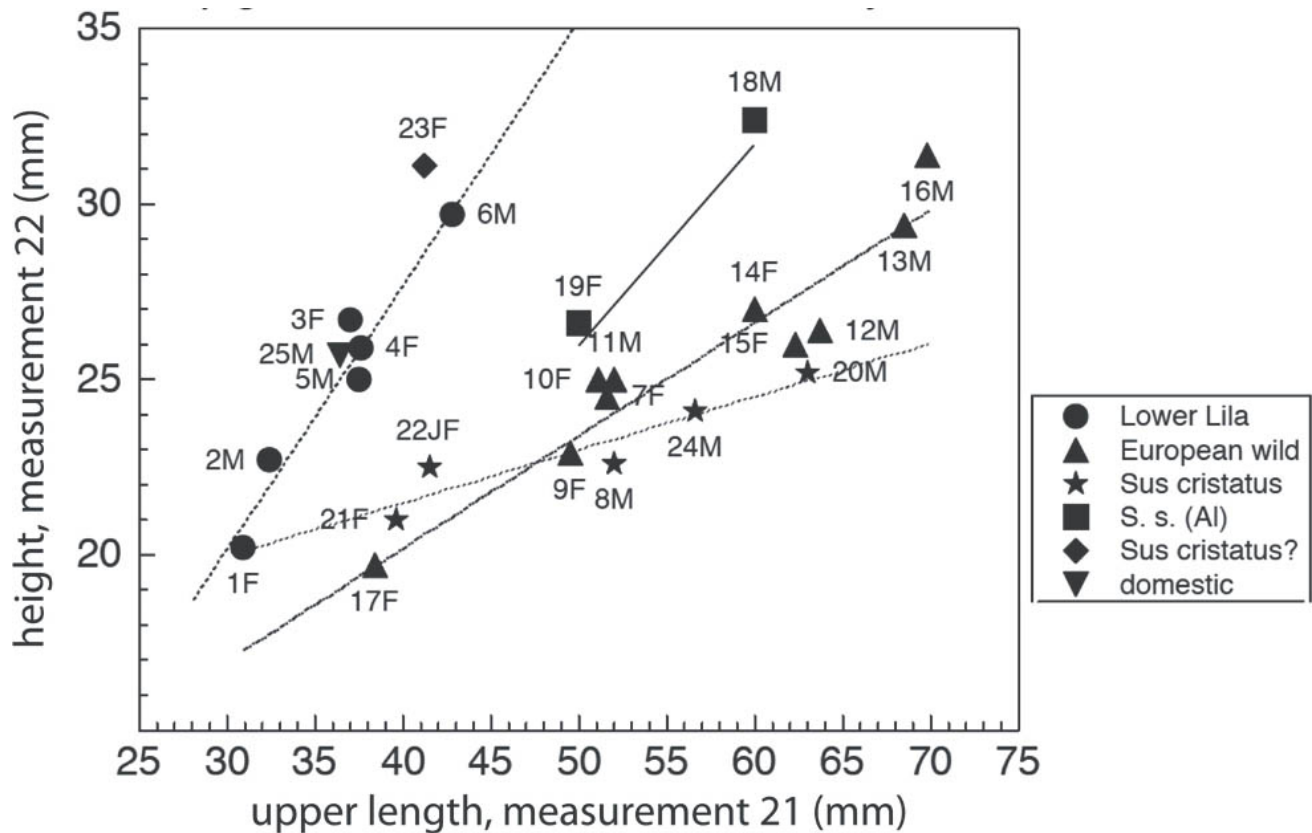


Fig. 7.13. Modern pig skulls: measurements of lachrymal bone, following the definitions of von den Driesch (1976, 39, figs. 12b–c).

Discussion

As noted above, the feral pigs of Australia are descended largely from British domestic stock. Recent evidence from mitochondrial DNA shows that the domestic pigs of Britain and northern Europe originated largely, if not entirely, from the local wild populations, while in northern India, China and South-east Asia, there were independent centres of pig domestication from the local wild populations (Larson *et al.* 2005; Chen *et al.* 2007). Further work on modern and ancient DNA will elucidate more fully the relationship between the various subspecies of *Sus scrofa*. Zeuner (1963) commented on the form of the lachrymal bone in the skull of pigs, saying that this is long in *Sus scrofa*, the wild pig of Europe and western Asia, but is short in the wild pig of South-east Asia, *Sus vittatus*. He further stated that this bone is of intermediate form in Mediterranean wild pigs, though not citing the source of metrical data to show that this is indeed so, saying only that ‘Much has been written about the significance of the shape of this bone in the pig’ (Zeuner 1963, 256). However, this proposition may be questionable.

Clutton-Brock (1999) illustrates the difference in the form of the lachrymal bone in the European boar, *Sus scrofa scrofa*, and the Indian form, *Sus scrofa cristatus*, though the source of the specimens illustrated there is not given. Her diagram (1999, 91–93 and fig. 8.3) shows the lachrymal bone of *Sus scrofa scrofa* as being relatively longer than it is high, while in *Sus scrofa cristatus* the two measurements of this bone are more nearly equal (the measurements used here are based on von den Driesch 1976, 39, figs 12b–c).

This difference was also described by McFadyean in 1888:

‘In the wild pig and the coarser races the lachrymo-frontal suture is much longer than the lachrymo--maxillary suture, but in the finer breeds the latter suture may equal or exceed the former in length’. (McFadyean 1888, 98)

The margins of the lachrymal bone in both wild and domestic pigs (Fig. 7.12) are of highly variable form so that this cannot be a very exact measurement. However, this small sample of Australian feral pigs has lachrymal bones in which the length is an average of 1.44 times the height, while in the sample of wild pigs (five European and four Indian) the length measurement is on average twice that of the height (Fig. 7.13). The right and left lachrymal bones may show some degree of difference in the same skull. While McFadyean might have considered the Australian feral pigs to be of ‘coarse’ breeding, they nonetheless are quite separate from the wild pigs, both European and Indian, on this measurement. The wild pigs from the Indian sub-continent are not notably different from the European wild boars, contrary to Clutton-Brock’s suggestion. Three of the European wild boar (juvenile #336 and adults #323 and #500) are from the reference collection at the Clark Laboratory, McDonald Institute of Archaeological Research, University of Cambridge. These skulls are from animals raised under farm conditions.

The Australian pigs are well grown, with two adult males (LL8 and LL 9) equalling or exceeding the weight for two free-living populations of European male wild boar. An older female (LL1) is also larger than European wild females, while two young adult females (LL4 and LL7) are somewhat smaller. It is well known that body size in pigs is highly dependent on food supply; see for example Mattioli and Pedone (1995), who found that enclosed wild boar, living at high density (160/km²) and with no supplemental feeding, were little more than half the body weight of the free-living population in the same region.

Some additional specimens of wild boar

A female wild boar from Spain

This specimen, in the author’s collection (Fig. 7.14 top), was shot in Zaragoza Province, Spain, in 1984 and the cranium was later given to the author. The precise place and date of killing is not known except that, from the information given, this was in Aragon. The specimen is included as an interesting comparison for the wear shown by LL Pig 2, which shows very much faster tooth wear than the Spanish specimen, presumably reflecting different sedimentary conditions in each environment.

Mandibular tooth wear (Grant numeric stages):

$P_2=Er$	$P_3=a$	$P_4=a$	$M_1=b$	$M_2=a$	$M_3=Cr$	MWS
			TWS=7	TWS=6	TWS=1	14

Maxilla: the maxilla has the adult tooth row P2 to M2. However, all of the cheek teeth have slight enamel wear only or no visible wear.

A large wild male from Jhansi, India

This specimen (Fig. 7.14 bottom) was killed in India, the victim of a pig sticking expedition, in which

wild pigs were killed by spear thrust from horseback. The specimen was donated to the Clark Laboratory, Department of Archaeology, University of Cambridge, by Miss Mary Cra'ster, a former member of the museum curatorial staff there. Miss Cra'ster has informed me that the pig was killed by her father about the year 1930, in Jhansi province, Northern India. An account of this activity is given in *Pig Sticking or Hog Hunting* by Robert Baden-Powell (published 1889). Eighteen years later Baden-Powell established the Scouting Movement.



Fig. 7.14. top: wild Spanish sub-adult female; bottom: wild Indian adult male.

Mandible: the M₃ is fully erupted, with wear on all pillars. The M₁ is heavily worn, but not to the extent found in the feral pigs described above (see LL9, where extreme wear on the M₁ was reached before M₃ was fully erupted). The jaw has large canines, reaching about 75 mm above the bone.

Mandibular tooth wear (Grant numeric stages):

$P_2=b$	$P_3=d$	$P_4=e$	$M_1=j$	$M_2=f$	$M_3=d$	MWS
			TWS=14	TWS=11	TWS=9	34

Maxilla: the maxilla has the adult tooth row P² to M³. All of the cheek teeth are in wear. Wear on the M³ is present to the posterior cusp.

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A morphometric investigation of late Pleistocene and Holocene humeri of aoudad (Barbary sheep: *Ammotragus lervia*, Pallas 1777) recovered from the Haua Fteah, Cyrenaica, Libya

A. J. Legge[†] and C. M. Stimpson

Prologue

Chris Stimpson

At the behest of Graeme Barker and the Cyrenaican Prehistory Project, Tony Legge was the driving force in a systematic re-evaluation of the bones of large vertebrates recovered by Charles McBurney from the Haua Fteah, Libya. For a time, I assisted Tony in this effort and my duties included conducting analyses of morphometric data from the bones of aoudad (Barbary sheep) from the cave sequence and modern reference collections. All these data were diligently collected by Tony and to use publication jargon (which Tony would not approve of) he ‘designed the experiment’ described here. While Tony was a little suspicious of statistical analyses, which he generally regarded as a convoluted ‘smoke and mirrors’ practice, he was always keen to pursue any line of evidence to answer research questions with bones. After a little discussion, he encouraged me to ‘crunch the numbers’ on the data that he had collected to address two such questions.

As all who worked with him will confirm, Tony was extremely passionate about doing the best possible job with any assemblage of bones that crossed his desk. To that end I have no doubt that he would have taken issue with aspects of this paper and the way that I have written it up. He would have been vocal on the subject. This paper and I would have been better and anyone within earshot would have been thoroughly entertained. However, Tony was also particularly keen that zooarchaeological data sets, especially measurements, were made available to the research community as soon as practical. In formal and informal discussions of zooarchaeological papers in the Grahame Clark Lab in Cambridge, Tony would frequently exclaim: ‘But where’s the data?!!!’ (or words to that effect). When I received the invitation to contribute to this book, I could not think of a better way of honouring him: here’s the data, Tony.

Introduction

Large assemblages of bones and teeth were recovered during the excavation of the Haua Fteah

(Cyrenaica, Libya) by Professor Charles McBurney in the 1950s (McBurney 1967) and have been the subject of detailed study (e.g. Higgs 1967; Klein and Scott 1986; MacDonald 1997; Wall-Scheffler 2007). The sedimentary sequences in this large karstic cave are unparalleled in North Africa and materials recovered from the site date from the near-recent past to at least 80,000 years (Barker *et al.* 2009) and possibly 100,000 years before present (Douka *et al.* 2014; see also Moyer 2003). All dates reported here are referred to as thousands of calibrated years before present or 'ky BP'.

The bones from the McBurney excavations (presently archived in the Division of Archaeology, University of Cambridge) were the subject of systematic re-evaluation and inventory in parallel with renewed investigations of the Haua Fteah by the Cyrenaican Prehistory Project (CPP) under the direction of Professor Graeme Barker (e.g. Barker *et al.* 2008; 2009; 2010). This paper describes the results from a morphometric investigation of post-cranial remains (humerus) of one taxon, aoudad (or 'Barbary sheep'; *Ammotragus lervia*, Pallas 1777).

Skeletal elements from this idiosyncratic and phylogenetically-complex North African caprine (Cassinello 1998) have long been known as a common occurrence in deposits in North African cave sites (e.g. Higgs 1967). Aoudad bones were ubiquitous throughout the sequence of the Haua Fteah and dominate the assemblages of bones in terms of numerical abundance (Higgs 1967, 18; Klein and Scott 1986). In the re-evaluation of the archive, excluding isolated teeth, 3,318 of a total of 4,588 specimens (bones or fragments thereof) were attributed to this taxon (Legge unpublished data). Analyses of surface modifications including cut marks (Legge unpublished data) support the inference that the majority of these assemblages accumulated as a result of hominin subsistence behaviours (Higgs 1967, 16).

Aoudad live in family groups and are associated with rocky, precipitous habitats from sea level to below the snow line (Cassinello *et al.* 2006). The species has morphological characteristics that have been described as intermediate between sheep (*Ovis* spp.) and goats (*Capra* spp.), with behaviours that parallel those observed in non-domesticated forms of these taxa (Cassinello 1998). However, there is no evidence that aoudad have undergone any form of domestication, although an early Holocene attempt – inferred from coprolites and spherulites in a cave site (Uan Afuda) in the Tadrat Acacus (Libyan Sahara) – at management through 'forced penning' has been proposed (Di Lernia and Cremaschi 1996; Di Lernia 2001). Historically, two sub-species have been reported in Libya: the endemic (now extinct) *A. lervia fassini* was reported from rocky deserts, with relic populations of *A. lervia sahariensis* reported to survive in south-west Libya (Masseti 2010).

Aoudad appear to be non-selective feeders (Cassinello 1998) and are adapted to rare, patchily distributed resources in mountainous area in the Sahara. This trait, in tandem with a scarcity of competitors and predators, is likely to have facilitated the relatively rapid expansion of game populations that were introduced into relatively rich habitats in the USA and Spain (Cassinello *et al.* 2006) where they now pose a threat to native flora and fauna (e.g. Avecedo *et al.* 2007). The high relative abundance of aoudad bones recovered from the Haua Fteah suggests a long-standing presence of populations of these animals, until relatively recent times, in the Jebel Akhdar and that they were a year-round dietary staple for hominin visitors to the Haua Fteah (see also Wall-Scheffler 2007).

Aims

In light of the reported difficulties of separating the bones of different caprines in the Haua Fteah sequence, particularly in Neolithic and younger deposits (Higgs 1967; Klein and Scott 1986), new reference specimens (now housed in the Grahame Clark Zooarchaeology Laboratory, University of Cambridge) and morphometric data were collected by AJL (from *A. lervia sahariensis*, with the

permission and assistance of the Estación Experimental de Zonas Áridas [EEZA], Almeira) to aid in the re-evaluation and identification of aoudad remains in the archive.

Here we present the results of analyses that investigated two aspects. First, we investigated Eric Higgs's observation of morphological conservatism through time (Higgs 1967). Given the age/depth of the cave sequence and potential climatic and environmental shifts that attended this time series, Higgs considered the potential of variation in size of the skeletal remains of aoudad. At a fundamental physiological level, body temperature and body size are the two most important factors that impact on how animals function and Bergmann's Rule (Bergmann 1847) states that animals living in cooler climates tend to have larger body sizes than related taxa in warmer zones. While larger animals lose more heat, in absolute terms, small animals lose more heat per unit volume. Larger body size is therefore interpreted to be advantageous for heat retention as larger animals have proportionately less surface area to volume from which heat is radiated (e.g. Speakman and Thomas 2003). Post-Pleistocene size reduction is thus interpreted to reflect an adaptation to the overall warming that characterised the onset of the Holocene after cooler conditions in the Pleistocene. Was there any evidence in the samples from the Haua Fteah that aoudad in the Jebel Akhdar adapted in this way?

Table 8.1. Specimen codes, sex and measurements (mm) of breadth of the trochlea (Bt) and height of the lateral portion of the trochlea (Ht) of distal humeri of aoudad (Ammotragus lervia) from the modern comparative collection at the Estación Experimental de Zonas Áridas, Almeira (EEZA)

<i>Specimen</i>	<i>Bt</i>	<i>Ht</i>	<i>sex</i>
NC172F	36.3	21.0	♀
NC37F	36.8	21.1	♀
NC111F	37.4	21.2	♀
NC107F	36.4	21.3	♀
NC167F	36.8	21.6	♀
NC76F	37.1	21.8	♀
NC65F	38.7	21.9	♀
NC42F	38.8	22.1	♀
NC33F	37.9	22.1	♀
NC32F	37.4	22.1	♀
FNC4F	36.6	22.2	♀
NC39F	38.5	22.4	♀
NC21F	37.5	22.4	♀
FNC5F	35.7	22.5	♀
NC161F	38.3	23.1	♀
NC30F	38.6	23.9	♀
NC26F	40.4	24.0	♀
NC36M	43.4	25.2	♂
NC24M	43.1	25.6	♂
NC28M	44.2	25.7	♂
NC14M	41.4	26.2	♂
NC41M	45.8	26.6	♂
NC35M	45.1	27.1	♂
NC23M	46.4	28.3	♂

Higgs concluded that ‘There is no change in bone size from the earliest recorded measurable specimens in the Levallois-Mousterian layers to the Libyco-Capsian, and a similar size is found up to the Classical deposit’ (Higgs 1967, 18). Higgs’s figures are compelling, but investigation of this statement is complicated by the fact that, analytically, the bones of *Ammotragus*, *Ovis* and *Capra* were ‘lumped’ together as Caprini (perhaps testament to the difficulty of separating the bones of these taxa without reference material) and measurements were summarised. Within the constraints of the available samples (see Materials and methods, below) we investigated Higgs’ observation using measurements of distal humeri of aoudad as proxy.

Our second aim was to characterise the morphometric characteristics of sexual dimorphism in the humerus: this approach was initiated in the re-analysis of bones from the Haua Fteah by Klein and Scott (1986). Aoudad show marked sexual dimorphism: in a captive population (of Saharan provenance: *A. lervia sahariensis*), Cassinello (1998) reports a mean body weight for females of 41.34 ± 1.92 kg ($n = 42$) compared with a mean body weight of 82.07 ± 6.29 kg ($n = 20$) for males. Klein and Scott concluded that a bimodal distribution of measurements of aoudad humeri from the Haua Fteah ‘probably reflects sexual dimorphism’ (Klein and Scott 1986, 534), but morphometric criteria were not published. These authors cautioned that, given relatively small sample sizes and that the data set was generated regardless of stratigraphic provenance, ‘It might thus mask important differences among cultural units’ (Klein and Scott 1986, 534). The re-evaluation of the site and the McBurney archive by the CPP produced a workable data set with some stratigraphic control. Here we present morphometric criteria from reference and identified archaeological specimens to determine the sex of aoudad humeri and investigate cultural units for such differences.

Table 8.2. Provenance, chronology and measurements (mm) of archaeological humeri assigned to female aoudad (*Ammotragus lervia*) recovered from the Haua Fteah, Cyrenaica, Libya

Year /spit ^a	layers ^a	date (ky BP) ^b	epoch	phase ^b	Bt	Ht	sex
55/3	IV VI VII	5.4–9.4	Holocene	Neolithic	38.1	22.3	♀
55/8–9	VIII	5.4–9.3	Holocene	Neolithic	37.7	22.4	♀
55/8–9	VIII	5.4–9.3	Holocene	Neolithic	37.2	23.0	♀
55/3	IV VI VII	5.4–9.4	Holocene	Neolithic	39.5	23.0	♀
55/8–9	VIII	5.4–9.3	Holocene	Neolithic	37.9	23.3	♀
51/4	Late Holocene	~ 5.4	Holocene	Neolithic	38.0	23.4	♀
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	35.5	21.6	♀
55/10	VIII X	5.4–12.7	Hol/Pl	Neo/Caps	39.2	22.2	♀
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	38.1	22.3	♀
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	37.6	22.4	♀
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	36.2	22.6	♀
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	38.9	23.0	♀
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	39.0	23.3	♀
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	40.6	23.3	♀
55/10	VIII X	5.4–12.7	Hol/Pl	Neo/Caps	38.5	23.5	♀
55/6	X	7.9–12.7	Hol/Pl	Capsian	38.1	22.5	♀
55/6	X	7.9–12.7	Hol/Pl	Capsian	37.3	22.7	♀
55/6	X	7.9–12.7	Hol/Pl	Capsian	38.3	23.3	♀
55/26	X	7.9–12.7	Hol/Pl	Capsian	39.1	23.9	♀
55/14	X XI XII	7.9–17.2	Hol/Pl	Caps/Oran	37.7	22.6	♀
55/17	XII XIV XV	12.5–17.2	Pleistocene	Oranian	37.6	21.8	♀
55/15	XI XII XIV XV	12.5–17.2	Pleistocene	Oranian	38.4	22.1	♀
55/15	XI XII XIV XV	12.5–17.2	Pleistocene	Oranian	40.5	22.4	♀
55/17	XII XIV XV	12.5–17.2	Pleistocene	Oranian	40.7	23.9	♀
52/8	XI XII	12.5–17.2	Pleistocene	Oranian	40.4	24.5	♀
55/18	XIV–XVIII	~ 12.5–17.2	Pleistocene	Oranian/Dabban	39.4	22.8	♀

^a Correlations for spits and layers from the McBurney excavations follow Stimpson (2011)

^b Chronology follows Douka *et al.* (2014)

Bt: breadth of the trochlea; Ht: height of the lateral portion of the trochlea

Table 8.3. Provenance, chronology and measurements (mm) of archaeological humeri assigned to male aoudad (*Ammotragus lervia*) recovered from the Haua Fteah, Cyrenaica, Libya

<i>Year /spit^a</i>	<i>layers^a</i>	<i>date (ky BP)^b</i>	<i>epoch</i>	<i>phase^b</i>	<i>Bt</i>	<i>Ht</i>	<i>sex</i>
55/3	IV VI VII	5.4–9.4	Holocene	Neolithic	41.4	24.6	♂
55/4	V VI VIII	5.4–9.4	Holocene	Neolithic	42.7	24.8	♂
55/4	V VI VIII	5.4–9.4	Holocene	Neolithic	42.1	26.0	♂
55/8–9	VIII	5.4–9.3	Holocene	Neolithic	45.8	26.5	♂
55/3	IV VI VII	5.4–9.4	Holocene	Neolithic	46.5	27.3	♂
55/8–9	VIII	5.4–9.3	Holocene	Neolithic	45.6	27.8	♂
55/8–9	VIII	5.4–9.3	Holocene	Neolithic	45.8	27.8	♂
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	44.3	25.5	♂
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	41.6	25.6	♂
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	42.3	25.7	♂
55/10	VIII X	5.4–12.7	Hol/Pl	Neo/Caps	44.8	26.6	♂
55/10	VIII X	5.4–12.7	Hol/Pl	Neo/Caps	46.0	27.0	♂
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	44.6	27.2	♂
55/10	VIII X	5.4–12.7	Hol/Pl	Neo/Caps	46.6	27.4	♂
55/5	VI VII X	5.4–12.7	Hol/Pl	Neo/Caps	45.7	27.7	♂
55/10	VIII X	5.4–12.7	Hol/Pl	Neo/Caps	44.6	28.2	♂
55/6	X	7.9–12.7	Hol/Pl	Capsian	45.2	25.5	♂
52/6	X	7.9–12.7	Hol/Pl	Capsian	43.8	26.0	♂
55/11	IX X	7.9–12.7	Hol/Pl	Capsian	44.0	26.1	♂
55/6	X	7.9–12.7	Hol/Pl	Capsian	44.4	26.2	♂
55/6	X	7.9–12.7	Hol/Pl	Capsian	41.7	26.5	♂
55/6	X	7.9–12.7	Hol/Pl	Capsian	46.3	26.6	♂
55/6	X	7.9–12.7	Hol/Pl	Capsian	43.9	26.7	♂
55/6	X	7.9–12.7	Hol/Pl	Capsian	45.8	27.5	♂
55/13	X XI XII	7.9–17.2	Hol/Pl	Caps/Oran	46.8	26.9	♂
55/13	X XI XII	7.9–17.2	Hol/Pl	Caps/Oran	44.6	25.9	♂
55/13	X XI XII	7.9–17.2	Hol/Pl	Caps/Oran	44.8	26.0	♂
55/14	X XI XII	7.9–17.2	Hol/Pl	Caps/Oran	45.3	26.6	♂
52/7	X XI XII	7.9–17.2	Hol/Pl	Caps/Oran	45.0	27.6	♂
52/7	X XI XII	7.9–17.2	Hol/Pl	Caps/Oran	45.3	28.1	♂
52/8	XI XII	12.5–17.2	Pleistocene	Oranian	42.8	25.0	♂
52/8	XI XII	12.5–17.2	Pleistocene	Oranian	41.4	25.1	♂
55/83	XIV XV	12.5–17.2	Pleistocene	Oranian	41.8	26.4	♂
55/83	XIV XV	12.5–17.2	Pleistocene	Oranian	40.8	24.8	♂
55/18	XIV–XVIIA	~ 12.5–17.2	Pleistocene	Oranian/Dabban	47.2	27.8	♂

^a Correlations for spits and layers from the McBurney excavations follow Stimpson (2011)

^b Chronology follows Douka *et al.* (2014)

Bt: breadth of the trochlea; Ht: height of the lateral portion of the trochlea

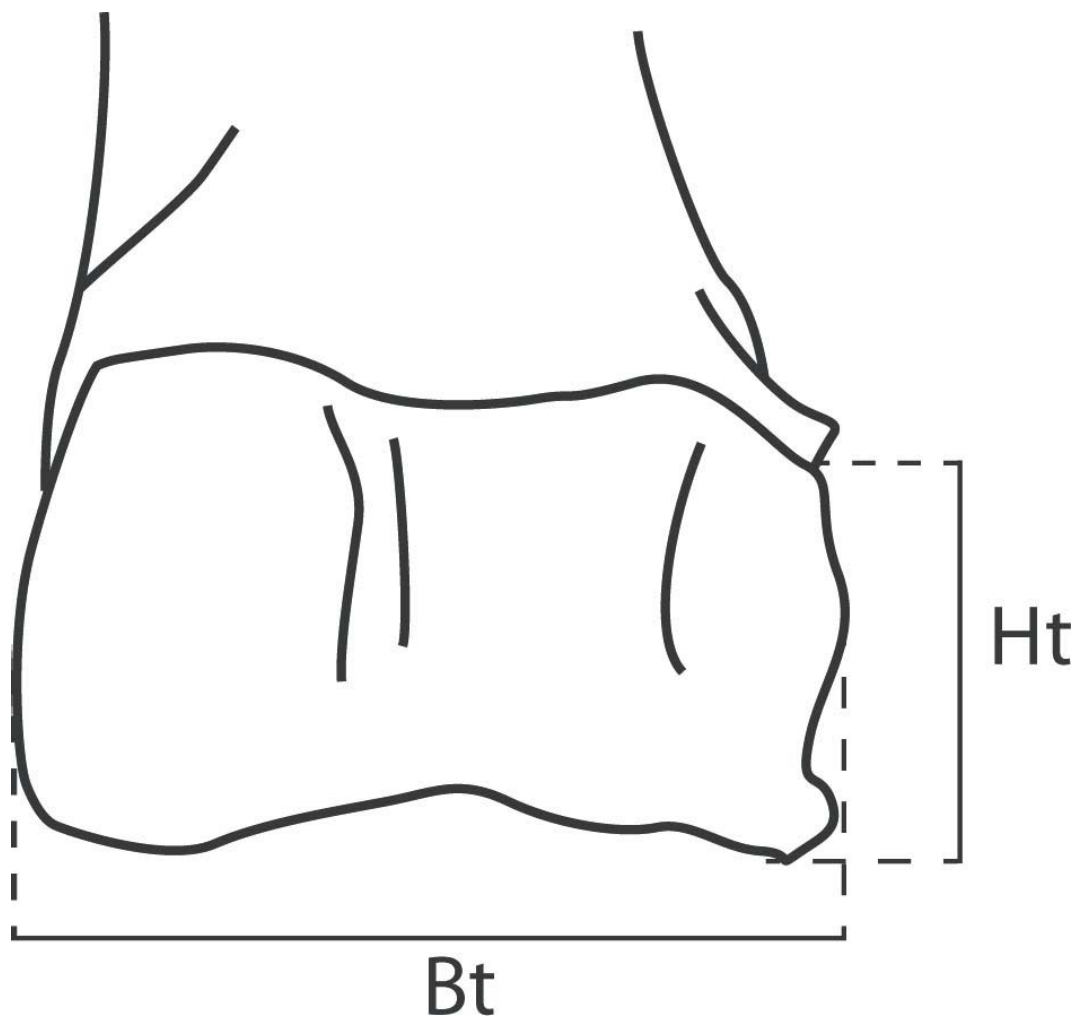


Fig. 8.1. Location and definition of measurements Bt and Ht of the distal humerus of *Ammotragus lervia*.

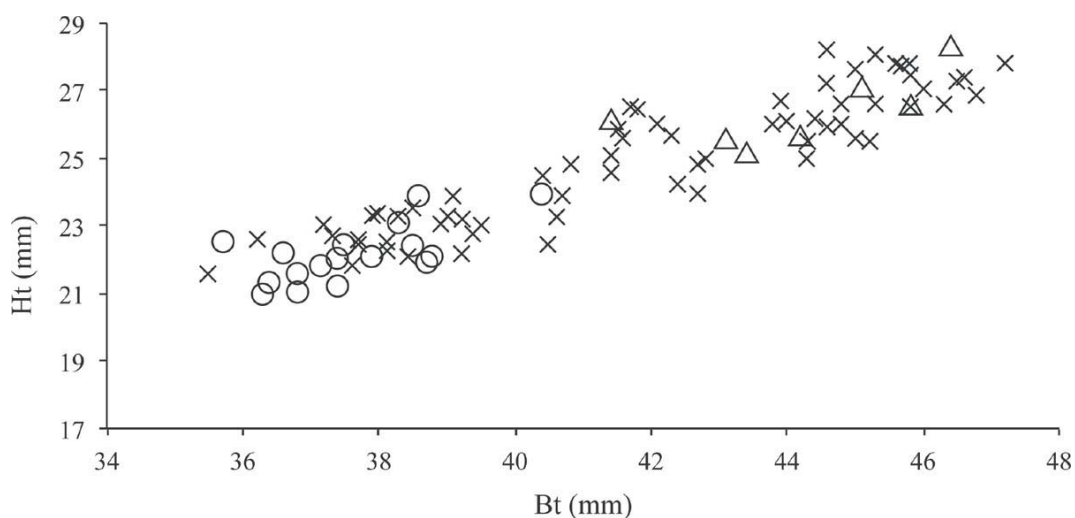


Fig. 8.2. Bivariate plot of Bt and Ht measurements (mm) of the distal humerus of *Ammotragus lervia*, comparing late Pleistocene and Holocene archaeological specimens from the Haua Fteah with modern specimens (*A. lervia sahariensis*) of known sex from EEZA. Key: open circles – modern females; open triangles – modern males; crosses – archaeological specimens

Materials and methods

Measurements of the humerus were taken from a total of 24 reference specimens (seven males and 17 females) from the EEZA collections (Table 8.1). A total of 62 humeri supplied secure measurements in the archaeological material from the Haua Fteah: specimens that were ultimately assigned as female are shown in Table 8.2 and specimens assigned as male are shown in Table 8.3.

Two measurements of the humerus were defined and selected for analysis by AJL (Fig. 8.1) as they provided the largest available data set for the Haua Fteah archive at the time of the re-evaluation: 'Bt' (breadth of the trochlea) and 'Ht' (height of the lateral portion of the trochlea). All measurements and collection of data were carried out by AJL. Measurements of archaeological and reference specimens were taken with digital callipers and rounded to the nearest 0.10 mm. Bivariate data were plotted with data from the EEZA comparative specimens (Fig. 8.2) and univariate frequency distributions were generated for each measurement (Figs 8.3 and 8.4 respectively).

Chronological and palaeo-climatic context

A well-documented and much-lamented aspect of analyses of archaeological materials recovered during the McBurney investigations of the Haua Fteah relates to excavation methodology (e.g. Klein and Scott 1986). McBurney excavated in spits (i.e. did not follow the stratigraphic layers of the site, but rather excavated in arbitrary units that produced time-averaged and mixed assemblages of material) and the establishment of a time series for the archaeological specimens considered here was constrained by this methodology. It was informed, however, by re-investigation by the CPP, the availability of new radiocarbon and OSL dates and the new chronology for the site proposed by Douka *et al.* (2014).

Despite the age/depth of the McBurney excavations and the apparent ubiquity of the remains of aoudad throughout the cave sequence, spit and layer correlations for the McBurney excavations (Stimpson 2011) indicate that the available samples of measurable humeri in the archive derived from deposits dated no earlier than the Dabban phase of occupation in the late Pleistocene (Tables 8.2 and 8.3). Summaries of numbers of identified specimens by Higgs (1967) and Klein and Scott (1986) and the re-evaluation of the archive (Legge unpublished data) all indicate that the most abundant concentrations of bones were recovered toward the upper layers of the cave sequence: this is consistent with a postulated increase in intensity of occupation of the cave following the Last Glacial Maximum (Barker *et al.* 2009). Taphonomic issues notwithstanding, it was therefore unsurprising that secure measurements of a single portion of a single skeletal element were also derived from the levels in the cave that yielded the largest sample sizes. The majority of the samples derived from layers younger than the Last Glacial Maximum (LGM) c. 19–23 ky BP and incorporated the Neolithic, Capsian and Oranian cultural phases with rare specimens from mixed phases of Oranian and Dabban. Given McBurney's excavation via arbitrary spits, some of these specimens were derived from spits that 'mixed' material from different cultural phases (Tables 8.2 and 8.3).

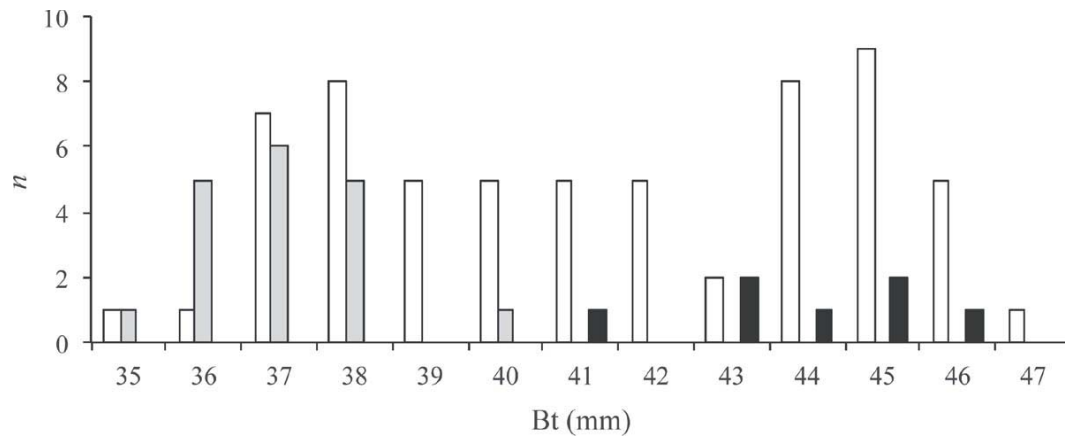


Fig. 8.3. Frequency distribution of Bt measurements (mm) of the distal humerus of *Ammotragus lervia*, comparing late Pleistocene and Holocene archaeological specimens from the Haua Fteah with modern specimens (*A. lervia sahariensis*) of known sex from EEZA. Key: grey columns – modern females; black columns – modern males; white columns – archaeological specimens

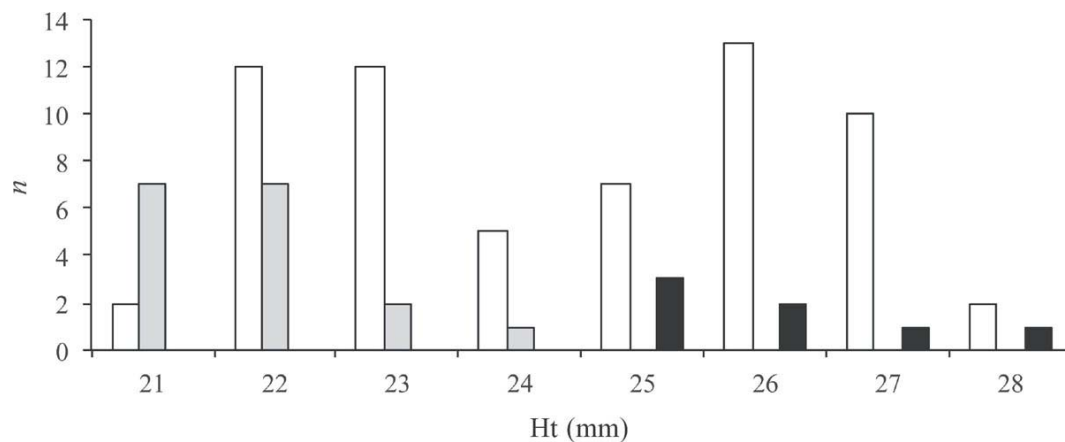


Fig. 8.4. Frequency distribution of Ht measurements (mm) of the distal humerus of *Ammotragus lervia*, comparing late Pleistocene and Holocene archaeological specimens from the Haua Fteah with modern specimens (*A. lervia sahariensis*) of known sex from EEZA. Key: grey columns – modern females; black columns – modern males; white columns – archaeological specimens

From a palaeo-climatic perspective, the sample encompasses the global, long-term trend of transition from cold, glacial conditions in the late Pleistocene to warmer temperatures that characterised the onset of the Holocene c. 11.6 ky BP (see also Wall-Scheffler 2007 for a proxy for the Haua Fteah and environs). However, the Mediterranean Basin, North Africa and the Near East are at the interface between low and high latitude climatic influences and modelling Quaternary palaeoclimates of these areas is complex (e.g. Tzedakis 2007).

A synthesis of palaeoclimatic records (undertaken in the context of global trends) from the Eastern Mediterranean and the Levant from 25 ky BP to the late Holocene (Robinson *et al.* 2006) suggests that Heinrich Event 2 (23.8 ky BP) and the Last Glacial Maximum (23–19 ky BP) were characterised by relatively cold and arid conditions. The evidence for Heinrich Event 1 (c. 16 ky BP) is less clear, but was also probably cold and arid. Relatively cold and arid conditions were punctuated by warmer and wetter episodes during the Bølling-Allerød (c. 13–15 ky BP).

North-west African records for the period between 14.8 ky BP and 5.5 ky BP correspond to the African Humid Period (AHP) – the onset and termination of which was abrupt and possibly in the

order of decades or centuries (deMenocal *et al.* 2000). The AHP was punctuated by the Younger Dryas (12.7–11.5 ky BP), which was extremely arid and likely cold when compared to the Bølling-Allerød and Holocene. The Levant and Eastern Mediterranean also apparently experienced a significant increase in rainfall in a warm and wet period in the early Holocene (9.5–7 ky BP) that may have included a sudden cooling and drying episode c. 8.2 ky BP. A brief mid-Holocene wet event may have occurred c. 5 ky BP, but proxy data for North Africa at this time indicate reduced precipitation, a relatively rapid collapse of vegetation communities and the onset of aridity thereafter (Liu *et al.* 2007).

Morphological conservatism and sexual dimorphism

Investigation of Higgs' assertion of morphological conservatism proceeded in two steps. Statistical treatment of data, following the conventions in Hammer and Harper (2006) and Zar (2010), was carried out by CS using functions in PAST (Hammer *et al.* 2001).

Table 8.4. Summary statistics for Bt (breadth of the trochlea) and Ht (height of the lateral portion of the trochlea) measurements (mm) of the distal humerus of female and male aoudad (Ammotragus lervia) from the EEZA comparative collections and total archaeological sample from the Haua Fteah

		♀		♂	
		<i>Bt</i>	<i>Ht</i>	<i>Bt</i>	<i>Ht</i>
EEZA	<i>n</i>	17	17	7	7
	range	35.7–40.4	21.0–24.0	41.4–46.4	25.2–28.3
	mean	37.602	22.158	44.2	26.386
	<i>s</i>	1.178	0.873	1.727	1.061
Haua Fteah	<i>n</i>	26	26	36	36
	range	35.5–40.7	21.6–24.5	40.8–47.2	24.2–28.2
	mean	38.442	22.85	44.269	26.422
	<i>s</i>	1.285	0.683	1.799	1.070

First, the data set was examined before analytical decisions were made on determining the likely sex of individual specimens. Each measurement in chronologically-sorted samples incorporating all (i.e. unsexed, bimodal distributions) specimens was subjected to non-parametric tests (Mann-Witney *U*; Kruskal-Wallis *H*) for differences in median values. The tests were carried out between unequivocally (i.e. non-mixed) Holocene (<11.6 ky BP) and Pleistocene-age samples (>11.6 ky BP) and then by cultural phase, first by excluding and then including samples from mixed phases (Tables 8.2 and 8.3).

The archaeological specimens were then separated into female and male categories using estimates generated by K-means cluster analyses (bivariate data) and mixture analysis (univariate data) functions in PAST and the characteristics of the distributions for male and female measurements from the EEZA collections (Figs 8.2–8.4; Table 8.4). Measurements in male and female categories were parsed into a maximum of five mixed and unmixed phases and tested with parametric statistics (One-way Anova). The archaeological data were also compared with data from the EEZA specimens as a modern comparative sample.

Results

The bivariate plot of measurements from the archaeological specimens shows two relatively indistinct clusters. Reference to EEZA comparative data suggests that the archaeological sample consisted of female and male specimens (Fig. 8.2). The univariate data for each measurement in the archaeological material have bimodal distributions (Figs 8.3 and 8.4, respectively): Ht measurements appear to provide finer resolution and less variance. Data from the EEZA comparative specimens also suggest the presence of female and male specimens in the archaeological sample (Figs 8.3 and 8.4).

Table 8.5. Summary statistics for Bt (breadth of the trochlea) and Ht (height of the lateral portion of the trochlea) measurements (mm) of the distal humerus of female and male aoudad (Ammotragus lervia) in chronological categories (sorted by cultural phase) from the Haua Fteah. Summary statistics from modern comparative specimens from EEZA are also shown

	Modern (EEZA)		Neolithic		Neo/Caps		Capsian		Caps/Ora		Oranian		Oran/Dabban	
	Bt	Ht	Bt	Ht	Bt	Ht	Bt	Ht	Bt	Ht	Bt	Ht	Bt	Ht
♀														
n	17	17	6	6	9	9	4	4	1	1	5	5	1	1
min	35.70	21.00	37.20	22.30	35.50	21.60	37.30	22.50	/	/	37.60	21.80	/	/
max	40.40	24.00	39.50	23.40	40.60	23.50	39.10	23.90	/	/	40.70	24.50	/	/
mean	37.60	22.16	38.07	22.90	38.18	22.69	38.20	23.10	37.70	22.60	39.52	22.94	39.40	22.80
s	1.18	0.87	0.77	0.46	1.57	0.63	0.74	0.63	/	/	1.42	1.19	/	/
♂														
n	7	7	8	8	9	9	8	8	6	6	4	4	1	1
min	41.40	25.20	41.40	24.20	41.60	25.50	41.70	25.50	44.60	25.90	40.80	24.80	/	/
max	46.40	28.30	46.50	27.80	46.60	28.20	46.30	27.50	46.80	28.10	42.80	26.40	/	/
mean	44.20	26.39	44.04	26.13	44.50	26.77	44.39	26.39	45.30	26.85	41.70	25.33	47.20	27.80
s	1.73	1.06	2.07	1.46	1.64	0.98	1.43	0.59	0.78	0.87	0.84	0.73	/	/

Un-sexed samples – non-parametric tests

Non-parametric testing of the total (un-sexed) data set did not suggest significant differences between the median values of Bt or Ht measurements in Holocene and Pleistocene samples from the Haua Fteah (Holocene $n = 14$, Pleistocene $n = 11$; Mann-Whitney U : Bt $U = 72.5$, $p = 0.827$; Ht $U = 66$, $p = 0.562$) and did not suggest differences in the measurements parsed in unmixed phases (Neolithic $n = 14$, Capsian $n = 12$, Oranian $n = 9$; Kruskal-Wallis H corrected for ties: Bt $H_c = 1.824$, $p = 0.402$; Ht $H_c = 2.843$, $p = 0.241$) or when mixed phases were included (Neolithic $n = 14$, Neolithic/Capsian $n = 18$, Capsian $n = 12$, Capsian/Orianian $n = 7$, Oranian $n = 9$, Oranian/Dabban $n = 2$; Kruskal-Wallis H corrected for ties: Bt $H_c = 5.99$, $p = 0.307$; Ht $H_c = 6.054$, $p = 0.301$).

Sexed samples – parametric tests

Summary statistics for Bt and Ht measurements for female and male specimens from the EEZA comparative collections and total archaeological sample from the Haua Fteah are shown in Table 8.4. Summary statistics for the archaeological specimens from the Haua Fteah sorted by cultural phase are shown in Table 8.5.

Female

Tests of Bt and Ht measurements from female archaeological specimens parsed into four categories (the Capsian/Oranian and Oranian/Dabban categories only contained one observation each and were parsed with the Oranian category) suggested there was no significant difference in measurements between the categories (One-way Anova: Bt $F = 1.295$, $p = 0.301$; Ht $F = 0.330$, $p = 0.804$) and no significant difference was suggested when the EEZA specimens were included in the data set (One-way Anova: Bt $F = 2.230$, $p = 0.084$; Ht $F = 2.203$, $p = 0.087$).

Male

Tests of Bt and Ht measurements from male archaeological specimens parsed into five categories (the single observation for the Oranian/Dabban was parsed with the Oranian category) suggested there was no significant difference between categories (One-way Anova: Bt $F = 1.483$, $p = 0.231$; Ht $F = 1.028$, $p = 0.408$) and no significant difference was found when the EEZA specimens were included in the data set (One-way Anova: Bt $F = 1.193$, $p = 0.331$; Ht $F = 0.826$, $p = 0.539$).

Discussion

Non-parametric testing of the unsexed samples did not suggest that there were differences in median Bt and Ht measurements between epochs, unmixed phases or when mixed phases were included. Parametric testing of sexed samples also did not suggest significant differences between mean measurements from specimens in chronologically-sorted archaeological samples, or when data from the EEZA (modern) collection were included.

It is important to remember that while a statistical procedure may (or may not) yield a ‘significant’ result, it is quite another matter to consider if that result is biologically (e.g. Yoccoz 1991; Sterne and Davey Smith 2001) or archaeologically meaningful and there are limitations in our data sets that impose limitations on our conclusions.

First, in the context of the age/depth represented by the cave sequence of the Haua Fteah, the samples that were available for our analysis were relatively recent in age: most specimens were recovered from post-LGM deposits. We therefore cannot claim that our findings are representative of the Haua Fteah sequence in its entirety and, as per McBurney’s excavation strategy, the chronological resolution of our samples was relatively poor in relation to climatic records. For example, while we were able to differentiate between unequivocally Holocene and Pleistocene-age specimens, it was not possible to differentiate between the African Humid Period and Younger Dryas in our samples from mixed Neolithic/Capsian and Capsian phases. Secondly, observations by Higgs, Klein and Scott and our re-analysis suggest that the recovered specimens largely derived from aoudad that were exploited by hominins. Thus, the examined specimens were not only part of a recovered sample from an exploited population, but included only those specimens that survived in an adequate state of preservation to

supply secure measurements.

Given the samples and methods available to us, however, our analyses of two characters from a single skeletal element found no compelling evidence to question Higgs' assertion of morphological conservatism in the skeletal remains of aoudad recovered from the Haua Fteah or that there were significant differences between the archaeological and modern comparative samples. While the relationship between temperature and body size is a key-principle, the influence of the environment is multifactorial; there are other physiological and selective pressures (e.g. sexual selection) that constrain changes in morphology. It is also important to remember that aoudad are adapted to surviving in environments with scarce, ephemeral and patchily distributed resources. Introduction of populations of aoudad as game animals has suggested that aoudad are capable of surviving – indeed thriving – in different habitats.

We also did not detect any evidence of size differences in aoudad between cultural phases or evidence of a bias in the representation of the sexes (Table 8.5). We suggest that exploitation of aoudad around the Haua Fteah by hominins does not appear to have been influenced by, or to have varied as a function of, cultural phase or size or sex of animals.

Conclusion

We present morphometric data for two characters of the distal humerus of aoudad from archaeological sequences of the Haua Fteah and modern comparative specimens. Analyses of two measurements did not suggest any evidence of post-Pleistocene size reduction or morphological change in the aoudad or significant differences between the archaeological specimens and modern comparative specimens. We also did not find any evidence of significant difference in size or sex representation between the examined cultural phases from the Haua Fteah. Our findings are consistent with Eric Higgs' assertion of morphological conservatism in the skeletal remains of aoudad from the Haua Fteah.

We hope that the morphometric data presented here will prove useful as a comparative data set to others working on the skeletal remains of aoudad.

Acknowledgements

We thank the Cyrenaican Prehistory Project and Graeme Barker for his encouragement and support for the re-evaluation of the McBurney archive at Cambridge and the staff at the Estación Experimental de Zonas Áridas, Almeira for hosting AJL and for assistance with data collection. This study benefitted from the hard work of Ryan J. Rabett and Lisa Marlow in developing an inventory of the entire McBurney archive and from discussions with members of the CPP project, particularly Ryan J. Rabett and Brittany Walsh who were (and are) also instrumental in the re-evaluation of the McBurney bone archive. CS would like to thank Liz Wells for her support in the preparation of this paper.

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Towards a metrical distinction between sheep and goat astragali

Simon J. M. Davis

Heureusement l'anatomie comparée possédait un principe qui, bien développé, était capable de faire évanouir tous les embarras: c'était celui de la corrélation des formes dans les êtres organisés, au moyen duquel chaque sorte d'être pourrait, à la rigueur, être reconnue par chaque fragment de chacune de ses parties.'

'Fortunately comparative anatomy possessed a principle which, when developed, managed to remove all embarrassment: it was the correlation of forms in organized beings, whereby any organised being could eventually be recognised from any fragment of each of its body-parts'.

Georges Cuvier (1812) – *Recherches sur les ossements fossiles de quadrupèdes; où l'on établit les caractères de plusieurs espèces d'animaux que les révolutions du globe paraissent avoir détruites.*
Discours préliminaire. Paris, Deterville.

Introduction

Separating sheep bones from goat bones is the bane of many a zooarchaeologist's working life. These two related genera of bovids are both classified within the sub-family Caprinae and tribe *caprini*. Despite a probable 7 million year separation of the lineages that gave rise to sheep and goat (i.e., in the late Miocene; Randi *et al.* 1991; Bibi 2013), many of their bones are hard to identify to species. While considering the measurements of 894 well preserved and fully measurable caprine astragali from Neolithic Khirokitia in Cyprus (Davis 1984; 1989; 1994; in press a), I tried to find a metrical method to distinguish sheep astragali from goat astragali that could corroborate their identification already made using the well-known morphological criteria described by the late Joachim Boessneck (Boessneck *et al.* 1964; Boessneck 1969). These 894 astragali had already been separated on morphological grounds to 814 sheep and 80 goats. I experimented with various combinations of measurements, and their indexes, and this note will describe a promising metrical method. I have also tried to replicate the apparent separation of the Khirokitia specimens using modern securely identified caprine astragali from Cyprus, the mainland Near East, Portugal, Greece and Britain. Finally I revisited caprine astragali identified, some probably incorrectly, by me from four archaeological sites in Portugal and one in Israel.

In order to be useful, a metrical method for separating sheep and goat bones needs to satisfy the following four conditions as Sebastian Payne (1969) outlined in his metrical distinction between sheep

and goat metacarpals:

- The relevant bone should be reasonably common in archaeological collections.
- It should not be likely to present a biased count for the relevant proportions of these two animals – thus the horn core in which some animals may be hornless or different in hardness leading to different rates of conservation is not recommended.
- The separation should be clear and easily reproduced by different observers – ideally it should be measurable.
- The distinction should apply to immature as well as mature bones.

Payne also suggested it is not necessary that all sheep should be separated from all goats but rather that, for a particular site, they can be separated into two discrete groups with relatively few intermediate specimens.

The purpose of this article is to outline a method which, at least in Cyprus, satisfies Payne's four criteria for identifying sheep and goat astragali. Astragali, being solid and compact, are generally well conserved and easily measured. The astragalus also attains adult size and shape early in the animal's development. The method appears to work reasonably well in Cyprus and several other regions today and/or in the past, but perhaps less well in others. It also appears to be unaffected by the age, sex and level of nutrition of the animal. This study has revealed some interesting variations, some of which may highlight areas worth further study. But first we need to ask, why is it important?

Sheep *versus* goats

Sheep and goats were among the first food animals domesticated and are often the most common on archaeological sites in Europe and the Near East. They are generally considered very differently by their keepers and may produce different things. Thus in Britain, sheep were long considered '... the mooste profytablest cattell that any man can haue' and valued for their carcass products – meat, skin, and tallow, as well as their dung, milk and wool (Fitzherbert 1534). However, the profit coming from goats '... is their milk, which is an excellent restorative, and their kids which are an excellent venison' (Markham 1657, 96). Today the Bakhtiari of Persia consider the goat to be the 'sheep of the poor' (Digard 1981, 28). In a discussion of the economics of nomadism in Iran, Stauffer (1965) writes that in terms of market yield the sheep is economically more desirable, as its wool and lambs command a higher price than either goat hair or kids. Goat hair is important in tent and carpet production but only two breeds of goat, the Angora and the Cashmere, produce wool (Mason 1984). Accessibility to markets is another factor that needs to be considered and may affect the sheep:goat ratio of flocks maintained in a settlement (Stauffer 1965; Gilbert 1975). Often the goat is the preferred animal where a family needs its products to survive, as goats produce more milk and have a higher reproductive rate. Goats too can thrive on coarser plant cover, on steeper and stonier terrain and require less careful husbandry. In Portugal the ratio sheep : goat may vary according to the nature of the terrain, soil fertility/vegetation. According to censuses conducted in Portugal in the 1930s, Orlando Ribeiro (1995, 356 and 404) noted that parishes situated in good pasture land tend to have more sheep than goats, while those on poorer land with abrupt slopes have more goats. For example in the mountainous area of Terras de Bouro (Gerês) there are 74 sheep and 154 goats per 100 inhabitants, while in the relatively flat countryside around Évora there are 256 sheep and only 12 goats per 100 inhabitants. These then

are some reasons why being able to discern sheep bones from goat bones in archaeological assemblages may aid their interpretation – the nature of the terrain and vegetation, the economy and even the wealth of the inhabitants. A sheep:goat ratio could perhaps be used as a kind of ‘index of wealth’. But how easy is it to identify their bones?

Identification of certain caprine bones to species level is possible. Examples include deciduous cheek teeth (dP3 and dP4), horn cores, distal humeri, distal metapodials and calcanea. These, as well as astragali, are *relatively* easy to identify (see for example the criteria described by Boessneck 1969; Payne 1969; 1985) and are the bones and teeth that I regularly record as sheep or goat, although, in my experience, errors are easily made.

Some anatomy

The astragalus is one of the tarsal bones in the heel of the foot linking the tibia to the cuboid and navicular bones which are in turn attached, via another small tarsal bone, to the metatarsals. The astragalus head is a keeled rolling surface or trochlea which fits into a corresponding set of grooves in the distal tibia. The joint is a hinge that does not permit any twisting, but allows a great amount of extension and flexion of the foot. A characteristic of the artiodactyls (unlike, for example, the perissodactyls) is their astragalus whose distal end *also* has a keeled rolling surface providing a great amount of backward and forward movement of the foot. Put another way, the artiodactyl astragalus constitutes part of a double hinge providing considerable flexibility and springing motion of the hind foot; thus facilitating rapid escape from predators – perhaps one of the reasons why this group has been so successful. The adjacent calcaneum, securely attached to the astragalus, has a powerful projection to which are attached the calf muscles via the ‘tendon of Achilles’ (Romer 1962; Barone 1986) – used by butchers to hang their ‘sides’ of meat.

In their general aspect the foot bones of the goat and sheep differ considerably. While the sheep with its long metapodials is adapted to fast running across flat land, the goat has shorter and more robust metapodials and is thus adapted to negotiating rocky escarpments. We shall see that these differences are reflected in their astragali, with the sheep astragalus being elongated along the limb’s length axis resulting in a relatively ‘greater’ value for the lateral depth.

Material

Modern (see Table 9.1 for a complete listing and their measurements)

It proved difficult to obtain modern autochthonous Cypriot sheep and goat skeletons. The three goat skeletons from Cyprus measured here are from the flock kept by a villager of Khirokitia and belonged to the Damascus breed or Damascus crosses. However, there are abundant wild mouflon – several from the reserve at Stavros tis Psokas in the Troodos Mountains, and many from a private collection. These are assumed to derive from domestic sheep introduced into the island many millennia ago in the Neolithic, as happened on several Mediterranean islands (Poplin 1979). Other modern sheep and goat skeletons measured include those of unimproved Shetland sheep (Davis, 1996; 2000; Popkin *et al.* 2012); assorted breeds of goats and Soay sheep from Britain in the Centre for Archaeology of English Heritage (formerly the Ancient Monuments Laboratory); a collection of Near Eastern (most from Israel) caprine astragali from Haifa University, Israel; local caprines from the island of Paros in the Cyclades (Greece), various breeds of caprines from Portugal all in the DGPC archaeological science laboratory in Lisbon (Portugal); feral goats from Mallorca (Spain) and also in the DGPC laboratory in

Lisbon; ibex (*Capra pyrenaica* from Jaén province in Spain) in the Natural History Museum of Madrid; and 31 wild sheep and wild goat from Iran and Iraq in the Field Museum, Chicago, USA.

Table 9.1. Measurements in tenths of a millimetre of modern sheep and goat astragali used in this study to corroborate the sheep-goat separation found in the sample from Khirokitia, Cyprus

<i>Taxon-Breed (Loc)</i>	<i>Country</i>	<i>Cat-No</i>	<i>Age/CA-fusion</i>	<i>Sex</i>	<i>GLI</i>	<i>Bd</i>	<i>DI</i>	<i>Meas-by</i>
CAH (France)	France	Pers-coll	very-juv	–	314	186	165	SJMD
CAH-feral (Pollença)	Mallorca, Spain	LARC-1563	F	f	294	182	155	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2639	ad/F	f?	303	191	166	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2640	juv/U	m?	278	176	149	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2641	juv/U	f?	282	179	142	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2642	s-ad/U	m?	321	198	167	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2643	ad/F	f?	287	183	148	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2644	ad/F	f?	291	178	151	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2645	juv/U	m?	312	195	151	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2646	juv/U	f?	283	180	154	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2647	juv/U	m?	310	197	163	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2648	juv/U	m?	302	191	155	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2649	ad/F	f?	317	197	158	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2650	ad/F	f?	295	178	151	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2651	juv/U	m?	310	190	172	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2652	juv/U	m?	313	209	166	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2653	s-ad/Fv	f??	317	196	164	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2654	ad/F	f?	310	185	161	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2655	juv/U	f?	308	197	164	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2656	juv/U	m?	338	213	183	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2657	juv/U	f?	291	183	143	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2658	juv/U	m?	298	198	155	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2659	juv/U	m??	247	158	131	SJMD
CAH-feral (La Trapa)	Mallorca, Spain	LARC-2660	juv/U	f?	307	184	159	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18104	juv	m	330	197	170	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18114	s-ad	f	314	189	162	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18155	ad	m	343	228	181	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18153	ad	m	340	215	185	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18152	ad	m	301	204	159	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18115	ad	f	314	193	161	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18130	ad	m	326	218	173	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18118	ad	f	300	186	161	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18124	ad	m	343	214	181	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18127	ad	m	320	197	169	SJMD
CAP-Ibex (Jaén)	Spain	MNCN 18087	ad	f	276	183	146	SJMD
CAH-Damasco	Cyprus	CfA-1631	juv	f	337	200	172	PB
CAH-Damasco	Cyprus	LARC-319	juv	–	350	222	181	SJMD
CAH-Damasco	Cyprus	SD-11/CfA-1631	200	f	344	206	168	SJMD
OVA (Episkopi)	Cyprus	Pers-coll [Kh]	ad	–	334	217	186	SJMD
OVM-Mouflon	Cyprus	LARC-15	F	m	284	182	158	SJMD

<i>Taxon-Breed (Loc)</i>	<i>Country</i>	<i>Cat-No</i>	<i>Age/CA-fusion</i>	<i>Sex</i>	<i>GLI</i>	<i>Bd</i>	<i>DI</i>	<i>Meas-by</i>
OVM-Mouflon	Cyprus	LARC-317	c. 90/U	m	269	163	155	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-111	ad	m	290	181	168	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-116	ad	m	282	177	165	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-118	ad	f	279	172	165	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-119	ad	m	298	185	170	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-122	ad	m	313	195	179	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-124	ad	f	267	165	151	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-127	ad	m	300	181	172	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-129	ad	f	264	164	155	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-13	ad	m	298	189	175	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-14	ad	m	289	186	168	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-157	ad	m	286	183	165	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-25	ad	m	295	188	177	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-34	ad	f	280	167	162	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-37	ad	f	281	172	156	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-37	ad	m	296	185	171	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-38	ad	m	295	188	176	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-42	ad	f	286	178	167	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-44	ad	m	288	184	169	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-55	ad	f	288	171	162	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-61	ad	f	292	180	168	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-73	ad	m	300	190	175	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-77	ad	m	299	171	170	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-79	ad	m	299	183	172	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-8	ad	m	305	187	176	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-81	ad	f	286	168	162	SJMD
OVM-Mouflon	Cyprus	Hadjisterkotis-93	ad	f	273	165	150	SJMD
OVM-Mouflon	Cyprus	Stavros-1 [Kh]	–	f	286	175	162	SJMD
OVM-Mouflon	Cyprus	Stavros-2 [Kh]	–	m	304	184	173	SJMD
OVM-Mouflon	Cyprus	Stavros-3 [Kh]	–	–	264	168	151	SJMD
CAH (?Scotland)	GB	CfA-45	ad	–	284	180	140	PB
CAH-feral (Islay)	GB	CfA-3318	ad	m	317	205	163	PB
CAH-feral (Islay)	GB	CfA-3323	ad	m	324	221	172	SJMD
CAH-Bagot	GB	CfA-2774	ad	m	305	206	154	PB
CAH-Guernsey x English	GB	CfA-2023	juv	–	306	188	163	PB
CAH-Old English	GB	CfA-2199	ad	m	339	207	172	PB
CAH-Toggenburg	GB	CfA-1315	ad	m	379	246	198	PB
CAH-White	GB	CfA-501	ad	m	316	201	169	PB
CAH-White	GB	CfA-502	ad	m	329	205	169	PB
OVA (Hoy, Orkney)	GB	Pers-coll	ad	–	275	180	149	SJMD

<i>Taxon-Breed (Loc)</i>	<i>Country</i>	<i>Cat-No</i>	<i>Age/CA-fusion</i>	<i>Sex</i>	<i>GLI</i>	<i>Bd</i>	<i>DI</i>	<i>Meas-by</i>
OVA-Soay	GB	CfA-1307	4272	f	253	165	139	PB
OVA-Soay	GB	CfA-1308	3916	f	260	163	148	PB
OVA-Soay	GB	CfA-1310	650	f	248	160	139	PB
OVA-Soay	GB	CfA-1311	3560	f	245	163	136	PB
OVA-Soay	GB	CfA-1312	ad	f	248	162	138	PB
OVA-Soay	GB	CfA-1317	1620	f	225	148	126	PB
OVA-Soay	GB	CfA-1487	ad	m	256	176	151	PB
OVA-Soay	GB	CfA-2224	1260	f	254	159	140	PB
OVA-Soay	GB	CfA-2225	2667	f	251	162	142	PB
OVA-Soay	GB	CfA-2226	4066	f	248	163	135	PB
OVA-Soay	GB	CfA-2227	3710	f	250	164	139	PB
OVA-Soay	GB	CfA-2228	1230	f	250	167	142	PB
OVA-Soay	GB	CfA-2229	1230	f	253	164	140	PB
OVA-Soay	GB	CfA-2438	3290	f	241	156	136	PB
OVA-Soay	GB	CfA-2509	2346	f	233	160	134	PB
OVA-Soay	GB	CfA-2510	3770	f	254	164	143	PB
OVA-Soay	GB	CfA-2552	3204	m	266	171	149	PB
OVA-Soay	GB	CfA-2688	3265	f	237	159	131	PB
OVA-Soay	GB	CfA-2773	970	c	240	166	138	PB
OVA-Soay	GB	CfA-2775	570	c	256	166	144	PB
OVA-Soay	GB	CfA-2776	3916	f	217	148	121	PB
OVA-Soay	GB	CfA-2778/LARC-2311	1355/F	f	235	158	131	SJMD
OVA-Soay	GB	CfA-2801	1055	c	247	169	139	PB
OVA-Soay	GB	CfA-2806	3560	f	229	150	128	PB
OVA-Soay	GB	CfA-2823	750	c	251	167	143	PB
OVA-Soay	GB	CfA-2832	4628	c	262	180	147	PB
OVA-Soay	GB	CfA-2844	4748	f	236	157	131	PB
OVA-Soay	GB	CfA-2945	ad	c	262	170	148	PB
OVA-Soay	GB	CfA-2946		c	259	180	142	PB
OVA-Soay	GB	CfA-2946	ad	c	259	180	142	PB
OVA-Soay	GB	CfA-2948	ad	c	264	174	147	PB
OVA-Soay	GB	CfA-3209	2642	f	238	152	132	PB
OVA-Soay	GB	CfA-3214	416	c	232	153	133	PB
OVA-Soay	GB	CfA-3262		c	252	164	139	PB
OVA-Soay	GB	CfA-3263	ad	c	276	176	155	PB
OVA-Soay	GB	CfA-3264	ad	c	267	177	152	PB
OVA-Soay	GB	CfA-3270	ad	c	273	164	148	PB
OVA-Soay	GB	CfA-3272	939	m	261	169	145	PB
OVA-Soay	GB	CfA-3273	ad	c	276	181	148	PB
OVA-Soay	GB	CfA-3275	ad	c	272	181	150	PB

<i>Taxon-Breed (Loc)</i>	<i>Country</i>	<i>Cat-No</i>	<i>Age/CA-fusion</i>	<i>Sex</i>	<i>GLI</i>	<i>Bd</i>	<i>DI</i>	<i>Meas-by</i>
OVA-Soay	GB	CfA-3297	300	f	233	146	131	PB
OVA-Soay	GB	CfA-3352	4200	f	246	151	137	PB
OVA-Soay	GB	CfA-3375	3344	f	222	148	126	PB
OVA-Soay	GB	CfA-3378	4300	f	226	152	131	PB
OVA-Soay	GB	CfA-3419	543	m	272	175	155	PB
OVA-Soay	GB	CfA-3420	ad	f	262	170	157	PB
OVA-Soay	GB	CfA-4115	ad	f	241	156	134	PB
OVA-Soay	GB	CfA-4116	Fv	f	263	175	151	PB
OVA-Soay	GB	CfA-4117	U	f	237	154	126	PB
OVA-Soay	GB	CfA-4118	ad	f	251	166	143	PB
OVA-Soay	GB	CfA-4119	s-ad	m	274	172	150	PB
OVA-Soay	GB	CfA-460	s-ad	m	273	175	157	PB
OVA-Soay	GB	CfA-549	ad	f	226	153	127	PB
CAH (Bet Gubrin)	Israel	Pers-coll	ad	–	290	187	155	SJMD
CAH-Baladi	Israel	Haifa-112/1067	5-6yrs	m	369	235	197	SJMD
CAH-Baladi	Israel	Haifa-152/1095	ad	f	338	203	177	SJMD
CAH-Baladi	Israel	Haifa-157/1095	ad	f	334	203	168	SJMD
CAH-Baladi	Israel	Haifa-168/1095	ad	f	322	209	166	SJMD
CAH-Baladi	Israel	Haifa-194/1095	ad	f	318	196	172	SJMD
CAH-Baladi	Israel	Haifa-36/1066	5-6yrs	f	345	212	185	SJMD
CAH-Ez Bait	Israel	Haifa-268/1103	ad	m	344	213	182	SJMD
CAH-Ez Bait	Israel	Haifa-320/1102	ad	f	348	222	183	SJMD
CAH-Ez Bait	Israel	Haifa-344/1102	ad	f	379	232	193	SJMD
CAH-Ez Bait	Israel	Haifa-347/1102	ad	f	376	230	193	SJMD
CAH-Ez Bait	Israel	Haifa-422/1102	ad	f	326	208	171	SJMD
CAH-Ez Bait	Israel	Haifa-429/1102	ad	f	356	232	189	SJMD
CAH-Ez Bait	Israel	Haifa-436/1102	ad	f	337	215	176	SJMD
CAH-Ez Bait	Israel	Haifa-437/1102	ad	f	338	212	172	SJMD
CAH-Ez Bait	Israel	Haifa-438/1102	ad	f	304	183	158	SJMD
CAH-Ez Bait	Israel	Haifa-440/1102	ad	f	315	208	165	SJMD
CAH-Ez Bait	Israel	Haifa-442/1102	ad	f	297	193	158	SJMD
CAH-Ez Bait	Israel	Haifa-460/1102	ad	f	357	219	181	SJMD
CAH-Ez Bait	Israel	Haifa-463/1102	ad	f	284	182	149	SJMD
CAH-Shami	Israel	Haifa-228/1087	12–24mo	m	344	214	185	SJMD
CAH-(north Negev)	Israel	HUJ-no number	ad	f?	260	171	138	SJMD
CAH-(west Galilee)	Israel	HUJ-no number	ad	f?	318	206	163	SJMD
CAH-Hejazi (Sinai)	Egypt	HUJ-2-VIII-77	ad	f	253	160	133	SJMD
Ibex	Israel	TA-M6588	ad	m	331	212	179	SJMD
Ibex (Nahal Tse'elim)	Israel	TA-6587	ad	f	277	173	150	SJMD
Ibex (Nahal Tse'elim)	Israel	HUJ-no number	ad	m	298	186	160	SJMD

<i>Taxon-Breed (Loc)</i>	<i>Country</i>	<i>Cat-No</i>	<i>Age/CA-fusion</i>	<i>Sex</i>	<i>GLI</i>	<i>Bd</i>	<i>DI</i>	<i>Meas-by</i>
OVA	Israel?	Haifa-627/1065	–	–	334	210	191	SJMD
OVA	Israel?	Haifa-819/1170	ad	–	383	247	206	SJMD
OVA (Luzit)	Israel	Pers-coll	ad	–	342	208	194	SJMD
OVA-Awassi	Israel	Haifa-704/1022	7yrs	F	320	217	188	SJMD
OVA-Awassi x Merino	Israel	Haifa-596/1038	3yrs	f	314	209	172	SJMD
OVA-Keves bait	Israel	Haifa-647/1057	–	m	335	222	193	SJMD
OVA-Keves bait	Israel	Haifa-670/1057	–	m	342	222	187	SJMD
OVO- <i>Ovis orientalis gmelini</i>	Armenia-Iran border	Haifa-538/1054	ad	f	311	190	169	SJMD
OVO- <i>Ovis orientalis gmelini</i>	Armenia-Iran border	Haifa-498/1158	ad	m	326	206	176	SJMD
CAH (Paros)	Greece	LARC-2512	ad	–	309	183	161	SJMD
CAH (Paros)	Greece	LARC-2513	juv/U	–	327	194	169	SJMD
CAH (Paros)	Greece	LARC-2514	juv/U	–	320	192	164	SJMD
CAH (Paros)	Greece	LARC-2515	juv/U	–	322	213	166	SJMD
CAH (Paros)	Greece	LARC-2547	ad/F	–	326	199	169	SJMD
CAH (Paros)	Greece	LARC-2627	juv/U	m	333	199	172	SJMD
CAH (Paros)	Greece	LARC-2628	juv/U	–	320	192	163	SJMD
CAH (Paros)	Greece	LARC-2629	juv/U	–	330	205	172	SJMD
CAH (Paros)	Greece	LARC-2633	juv/U	–	341	206	169	SJMD
CAH (Paros)	Greece	LARC-2637	?s-ad/?Fv	–	329	204	175	SJMD
CAH (Paros)	Greece	LARC-2675	juv/U	–	303	187	158	SJMD
CAH (Paros)	Greece	LARC-2676	juv/U	–	349	223	192	SJMD
CAH (Paros)	Greece	LARC-2677	ad/F	f	313	197	151	SJMD
CAH (Paros)	Greece	LARC-2678	juv/U	–	293	177	150	SJMD
CAH (Paros)	Greece	LARC-2679	juv/U	–	331	200	170	SJMD
OVA (Paros)	Greece	LARC-2516	juv/U	–	333	206	182	SJMD
OVA (Paros)	Greece	LARC-2517	juv/Fv	–	324	208	179	SJMD
OVA (Paros)	Greece	LARC-2518	juv/U	–	335	203	181	SJMD
OVA (Paros)	Greece	LARC-2519	juv/U	–	345	236	195	SJMD
OVA (Paros)	Greece	LARC-2520	ad	–	265	177	152	SJMD
OVA (Paros)	Greece	LARC-2551	juv/U	–	314	193	171	SJMD
OVA (Paros)	Greece	LARC-2565	c.90/U	–	310	204	165	SJMD
OVA (Paros)	Greece	LARC-2571	juv/U	–	322	197	178	SJMD
OVA (Paros)	Greece	LARC-2626	juv/U	–	295	190	159	SJMD
OVA (Paros)	Greece	LARC-2630	juv/U	–	336	209	178	SJMD
OVA (Paros)	Greece	LARC-2631	juv/U	–	302	196	169	SJMD
OVA (Paros)	Greece	LARC-2632	juv/U	–	312	199	181	SJMD
OVA (Paros)	Greece	LARC-2634	juv/U	–	326	222	184	SJMD
OVA (Paros)	Greece	LARC-2635	juv/U	–	308	198	180	SJMD
OVA (Paros)	Greece	LARC-2636	juv/U	–	312	216	181	SJMD

<i>Taxon-Breed (Loc)</i>	<i>Country</i>	<i>Cat-No</i>	<i>Age/CA-fusion</i>	<i>Sex</i>	<i>GLI</i>	<i>Bd</i>	<i>DI</i>	<i>Meas-by</i>
OVA (Paros)	Greece	LARC-2680	juv/U	–	327	213	177	SJMD
OVA (Paros)	Greece	LARC-2681	juv/U	–	335	218	189	SJMD
OVA (Paros)	Greece	LARC-2682	juv/U	–	325	212	178	SJMD
OVA (Paros)	Greece	LARC-2683	juv/U	–	309	190	162	SJMD
OVA (Paros)	Greece	LARC-2684	juv/U	–	303	187	172	SJMD
CAH (Beirão)	Portugal	LARC-2490	ad	f	300	187	154	SJMD
CAH (Gerês)	Portugal	LARC-loose	ad	–	274	189	143	SJMD
CAH (Guarda)	Portugal	LARC-2493	s-ad/F	f	296	182	151	SJMD
CAH (Souzel)	Portugal	LARC-2492	ad	f	350	224	185	SJMD
CAH (Souzel)	Portugal	LARC-2546	s-ad/F	m	332	194	162	SJMD
CAH-Serpentina	Portugal	LARC-1764	s-ad/U	f	355	219	185	SJMD
CAH-Serpentina	Portugal	LARC-2197	juv	f	340	194	174	SJMD
CAH-Serpentina	Portugal	LARC-2278	F	f	357	214	186	SJMD
CAH-Serpentina	Portugal	LARC-2279	F	f	314	194	160	SJMD
CAH-Serpentina	Portugal	LARC-2301	F	f	331	206	170	SJMD
OVA (Pedrogã)	Portugal	LARC-2552	juv/U?	m	345	214	188	SJMD
OVA (Souzel)	Portugal	LARC-2549	juv/U	–	351	226	193	SJMD
OVA (Souzel)	Portugal	LARC-2550	juv/U	–	339	218	185	SJMD
OVA (Souzel)	Portugal	LARC-2553	juv/U	–	380	244	199	SJMD
OVA (Souzel)	Portugal	LARC-2556	juv/U	–	355	232	194	SJMD
OVA (Souzel)	Portugal	LARC-2557	juv/U	–	328	227	187	SJMD
OVA (Souzel)	Portugal	LARC-2558	juv/U	–	347	239	192	SJMD
OVA (Souzel)	Portugal	LARC-2564	juv/U	–	352	242	193	SJMD
OVA (Souzel)	Portugal	LARC-2572	juv/U	–	361	233	201	SJMD
OVA (Vila de Rei)	Portugal	LARC-2548	juv/U	f	348	214	186	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1904	F	f	321	198	170	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1905	F	f	323	200	171	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1906	F	f	302	189	156	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1907	F	f	318	200	170	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1908	F	f	310	191	157	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1909	F	f	307	198	168	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1910	F	f	316	193	171	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1911	F	f	323	204	178	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1912	F	f	298	194	165	SJMD

<i>Taxon-Breed (Loc)</i>	<i>Country</i>	<i>Cat-No</i>	<i>Age/CA-fusion</i>	<i>Sex</i>	<i>GLI</i>	<i>Bd</i>	<i>DI</i>	<i>Meas-by</i>
OVA-Churra Terra Quente	Portugal	LARC-1913	F	f	317	199	172	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1915	F	f	327	202	170	SJMD
OVA-Churra Terra Quente	Portugal	LARC-1916	F	f	332	205	180	SJMD
OVA-Merino, black	Portugal	LARC-1658	2563/F	f	323	215	182	SJMD
OVA-Merino, black	Portugal	LARC-1659	4046/F	f	310	212	178	SJMD
OVA-Merino, black	Portugal	LARC-1660	1952/F	f	334	221	180	SJMD
OVA-Merino, black	Portugal	LARC-1661	1225/F	f	356	230	205	SJMD
OVA-Merino, black	Portugal	LARC-1662	3731/F	f	318	213	184	SJMD
OVA-Merino, black	Portugal	LARC-1663	1500/F	f	332	222	180	SJMD
OVA-Merino, black	Portugal	LARC-1664	3385/F	f	379	261	210	SJMD
OVA-Merino, black	Portugal	LARC-1665	3415/F	f	339	233	195	SJMD
OVA-Merino, black	Portugal	LARC-1666	1989/F	f	349	224	188	SJMD
OVA-Merino, black	Portugal	LARC-1667	1552/F	f	325	203	178	SJMD
OVA-Merino, black	Portugal	LARC-2198	Fv	m	351	229	193	SJMD
OVA-Merino, black	Portugal	LARC-2229	F	f	332	214	181	SJMD
OVA-Merino, white	Portugal	LARC-1750	2500/F	f	326	217	183	SJMD
OVA-Merino, white	Portugal	LARC-1762	2500/F	m	356	237	201	SJMD
OVA-Merino, white	Portugal	LARC-1763	2500/F	f	321	223	180	SJMD
OVA-Merino, white	Portugal	LARC-1802	2500/F	f	325	212	180	SJMD
OVA-Merino, white	Portugal	LARC-1808	2500/F	f	339	231	189	SJMD
OVA-Merino, white	Portugal	LARC-1809	2500/F	f	316	213	180	SJMD
OVA-Merino, white	Portugal	LARC-1810	2500/F	f	336	214	186	SJMD
OVA-Merino, white	Portugal	LARC-1811	2500/F	m	395	274	214	SJMD
OVA-Merino, white	Portugal	LARC-1812	2500/F	f	329	231	187	SJMD
OVA-Merino, white	Portugal	LARC-2196	F	f	384	253	212	SJMD
OVA-Merino, white	Portugal	LARC-2228	F	f	328	218	176	SJMD
OVA-Merino, white	Portugal	LARC-2230	F	m	351	236	204	SJMD
OVA-Merino, white	Portugal	LARC-2276	F	f	338	218	182	SJMD
OVA-Merino, white	Portugal	LARC-2559	juv/U	–	326	222	184	SJMD
OVA-Merino, white	Portugal	LARC-2560	juv/U	–	347	224	190	SJMD
OVA-Merino, white	Portugal	LARC-2561	juv/U	–	335	202	182	SJMD
OVA-Merino, white	Portugal	LARC-2562	juv/U	–	332	214	182	SJMD
OVA-Merino, white	Portugal	LARC-2563	juv/U	–	309	202	166	SJMD
OVA-Merino, white	Portugal	LARC-2566	juv/U	–	346	223	193	SJMD
OVA-Merino, white	Portugal	LARC-2567	juv/U	–	338	213	187	SJMD
OVA-Merino, white	Portugal	LARC-2569	juv/U	–	337	219	182	SJMD
OVA-Merino, white	Portugal	LARC-2570	juv/U	–	339	219	183	SJMD
OVA-Merino, white	Portugal	LARC-2573	juv/U	–	327	200	179	SJMD

<i>Taxon-Breed (Loc)</i>	<i>Country</i>	<i>Cat-No</i>	<i>Age/CA-fusion</i>	<i>Sex</i>	<i>GLI</i>	<i>Bd</i>	<i>DI</i>	<i>Meas-by</i>
OVA-Merino, white	Portugal	LARC-2574	juv/U	–	315	217	182	SJMD
OVA-Merino, white	Portugal	LARC-2575	juv/U	–	302	206	175	SJMD
OVA-Merino, white	Portugal	LARC-2581	juv/U	–	305	206	169	SJMD
OVA-Merino, white	Portugal	LARC-2582	juv/U	–	321	216	182	SJMD
OVA-Merino, white	Portugal	LARC-2583	uv/U	–	310	209	180	SJMD
OVA-Merino, white	Portugal	LARC-2593	juv/U	–	340	230	189	SJMD
OVA-Merino, white	Portugal	LARC-2594	juv/U	–	347	224	191	SJMD
OVA-Merino, white	Portugal	LARC-2595	juv/U	–	313	209	170	SJMD
OVA-Merino, white	Portugal	LARC-2596	juv/U	–	355	246	194	SJMD
OVA-Merino, white	Portugal	LARC-2597	juv/U	–	354	223	187	SJMD
OVA-Merino, white	Portugal	LARC-2598	juv/U	–	325	214	180	SJMD
OVA-Merino, white	Portugal	LARC-2599	juv/U	–	351	236	193	SJMD
OVA-Merino, white	Portugal	LARC-2600	juv/U	–	360	237	194	SJMD

The columns provide the following information (for Shetland sheep see Davis, 1996; 2000):

- Taxon-Breed (Loc): CAH domestic or feral goat, CAP Spanish Ibex, OVM Cypriot mouflon, OVO wild sheep, OVA domestic sheep, followed by breed, or where breed is unknown, the place of origin of the animal in brackets. The 22 feral goats from La Trapa in western Mallorca were collected and prepared by Alex Valenzuela and Josep Alcover.
- Country of origin.
- Cat-No: catalogue number, these being pers-coll (this author's personal collection), LARC (archaeological science laboratory collection of the DGPC, Lisbon), CfA (Centre for Archaeology, English Heritage, Portsmouth), MNCN (Natural History Museum, Madrid), Hadjisterkotis (Eleutherios Hadjisterkotis' collection of mouflon skeletons), Haifa (Archaeozoology lab collection in Haifa University, Israel), TA (zoology collection of Tel Aviv University, Israel) and several [labeled Kh] are in Khirokitia village, Cyprus. Note that among the goats from Paros, LARC-2677 was the mother of siblings LARC-2676 and LARC-2679. They are marked with asterisks in 9.2.
- Age/CA-fusion: Age in days or years followed by the state of fusion of the calcaneum-*tuber calcis* when known. Ibex numbers MNCN 18105 and 18114 are juvenile and sub-adult respectively with metapodials fused or fused with suture visible respectively. Both are in Payne (1973) tooth wear stage 'F'. All other Ibex in the MNCN collection are adults with tooth wear stages 'F' or more advanced.
- Sex. Note that one of the Paros goats was identified on the basis of its thick pubis as male (instead of merely purchasing the foot of this animal I bought the whole leg + pelvis).
- GLI: the greatest lateral length.
- Bd: distal width.
- DI: lateral depth.
- Meas-by: who took the measurements – PB (Polydora Baker, CfA, Portsmouth), SJMD (this author).

Archaeological

The site of Khirokitia on the island of Cyprus is situated near the modern village of the same name, 6 km inland from the southern coast. It was discovered by Porphyrios Dikaïos in 1934 and subsequently excavated by him (Dikaïos 1953). Culturally, ancient Khirokitia belongs to the 'Cypriot Recent Aceramic Neolithic' which appeared during the second half of the seventh millennium BC. The Aceramic Neolithic is probably the first culture represented on the island and the site of Khirokitia was once considered to have been the earliest settlement in Cyprus. But in the 1990s, more ancient, perhaps by as much as a millennium, Aceramic Neolithic sites were discovered and excavated (see for example Şevketoglu 2006; Vigne 2011). Khirokitia was dug between 1977 and 2007 by Alain Le Brun

and Odile Daune-Le Brun (see for example Le Brun 1984; and Le Brun *et al.* in press). Their excavations brought to light some 600,000 animal bones which include over 1,000 caprine astragali. Of these, 894 are well preserved, fully measurable and identifiable as sheep or goat although 58 were less securely identified (see the appendix for their measurements). Other archaeological specimens of caprine astragali examined using the metrical method described here are from four sites in Portugal – Lameiras (Neolithic; Davis *et al.* in prep.); Castro Marim (Iron Age and Roman; Davis 2007); Alcáçova de Santarém (Iron Age, Roman and Moslem; Davis 2006), and Silves (Moslem; Davis *et al.* 2008); a site in England – Launceston Castle in Cornwall, England (medieval and post-medieval; Albarella and Davis 1996); and the Bronze Age to Roman site of Tel Yarmout in Israel (Davis in press b).

Methods

This study uses three of the measurements on artiodactyl astragali that zooarchaeologists generally take and recommended by von den Driesch (1976) – greatest lateral length (GLI), distal width (Bd) and lateral depth (DI). Measurements were taken with vernier callipers to the nearest 0.1 mm. One important aspect of taking measurements is that each investigator may take her/his measurements in a different way. The importance of this factor has been emphasized by several biometricians. One of the first was Francis Sumner (1927) who referred to it as the ‘personal equation’ (see also Jewell and Fullagar 1966; and Yablokov 1974, 14–17). Zooarchaeologists may hold their callipers at a different angle and the points on a specimen across which the jaws of the callipers are laid may not always be the same. For this reason the person who measured each astragalus is shown in Table 9.1 – most were measured by this author as were the archaeological astragali from Khirokitia (see Appendix 9.1).

Instead of plotting scatter diagrams of simple measurements, the method uses indexes. These are DI/GLI plotted on the ‘y’ axis and Bd/DI plotted on the ‘x’ axis. Thus rather than size, shape is considered. As Thompson (1917) showed, differences between animals can be expressed mathematically as a difference in relative measurements (see Albarella 1997 for further discussion of the importance of shape in zooarchaeology).

Results and discussion

Sex, age and nutrition

Do nutrition, sex and age affect the shape of the astragalus and hence interfere with this method of separating sheep from goat? In order to determine the effect of these three factors I used the data from the large and comprehensive study of Shetland sheep bones undertaken by Popkin *et al.* (2012). Average values of the two indexes, DI/GLI and Bd/DI for the three sexes (male, female and castrate) and high and low levels of nutrition (Table 9.2) show few differences – i.e., neither nutritional variation nor sex significantly affect the astragalus shape in sheep. Age however does show a small difference for the index Bd/DI with older animals having a slightly higher value. Similarly, astragali of juvenile Portuguese Merinos are little different from astragali from adult animals (Fig. 9.1). The youngest slaughter class in the Popkin study was 6–7 months and most of the juvenile Merinos were slaughtered when 7–8 months (Alfredo Sendim, pers. comm.). Thus we do not know whether younger animals have a different shape. While this may indeed be the case, it is unlikely to be a problem in zooarchaeology since very young sheep and goats are rare; it is uneconomical to slaughter much below this age. The small change of the index Bd/DI with age however, is too small to seriously affect the metrical

separation of sheep from goat astragali indicated in this study. 11 female and nine male feral goat skeletons from Mallorca also indicate no astragalus shape variation with respect to sex.

Modern specimens of known identity

Britain (Fig. 9.2 top left)

Modern goats of assorted breeds appear to separate reasonably clearly from modern Soay sheep. However, some of the unimproved Shetland sheep measurements (Davis 1996; 2000) overlap those of the goats. It is interesting that the Shetland sheep appear on average to have shifted slightly in a clockwise direction on the graph when compared to the Soays. Indeed both Soay and Shetland sheep appear to be more similar to the goats via the 'x' axis, or, put another way, the relation between Bd and Dl is less distinct here for the sheep and goats than, say, in Cyprus as we shall see below.

Cyprus and the Near East (Fig. 9.2 top right)

The mouflon, *Ovis musimon*, and three Cypriot goats (these goats are of probable imported stock) plot in a similar way to the Neolithic sheep and goats from Khirekitia (see below). The modern sheep from the Levant are somewhat more goat-like while the modern Levantine goats are similar in shape to those from Neolithic Cyprus. In Cyprus the ratio Bd/Dl for sheep lies around an average value of c. 107 while in the Soays and Shetland sheep of Britain it lies around an average of c. 117 and c. 124 respectively – similar to the value of c. 120 for the domestic goats of Cyprus and Israel (see also Table 9.3)! These geographical differences emphasize the danger of using reference bones from different regions. It should be noted too that the three wild goat (*Capra ibex*; ibex) and the two wild sheep (*Ovis orientalis gmelini* originating from the Armenia–Iran border) astragali plotted on this graph indicate no separation of these wild taxa. We shall return to this problem – see under 'Iran and Iraq' below.

Table 9.2. The effects of sex, age and nutrition on the shape of modern Shetland sheep astragali. The average values of the two indexes – Dl/GLl and Bd/Dl – used in this study to separate sheep from goat astragali.

	DI/GLI	Bd/DI
Sheep with fused calcaneum- <i>tuber calcis</i> and 'High' nutrition only (effect of sex alone with age and nutrition controlled):		
Females	55.5 [81/1.31]	119.3 [81/3.00]
Males	55.5 [28/0.93]	119.6 [28/2.74]
Castrates	55.7 [28/1.27]	120.3 [28/2.44]
Sheep reared under 'High' and 'Low' nutrition combined (effect of age and sex with no control of nutrition):		
Females CA fused	55.5 [156/1.34]	118.9 [156/3.04]
Females CA unfused	55.3 [20/1.30]	117.6 [20/2.41]
Males CA fused	55.5 [54/1.10]	120.0 [54/2.68]
Males CA unfused	55.1 [29/1.25]	118.7 [29/2.78]
Castrates CA fused	55.6 [51/1.32]	120.1 [51/3.11]
Castrates CA unfused	55.2 [29/1.43]	118.3 [29/3.43]
Female sheep only (effect of age and nutrition upon females only):		
'High' nutrition CA fused	55.5 [81/1.31]	119.3 [81/3.00]
'High' nutrition CA unfused	55.6 [8/1.23]	117.1 [8/2.87]
'Low' nutrition CA fused	55.5 [75/1.38]	118.4 [75/3.04]
'Low' nutrition CA unfused	55.1 [12/1.35]	117.8 [12/2.14]
Males, females and castrates combined (effect of age and nutrition with no control of sex):		
'High' nutrition CA fused	55.2 [137/1.23]	119.6 [137/2.85]
'High' nutrition CA unfused	55.6 [32/1.43]	118.4 [32/3.44]
'Low' nutrition CA fused	55.5 [124/1.36]	119.1 [124/3.20]
'Low' nutrition CA unfused	55.1 [46/1.34]	118.1 [46/2.80]

These values are calculated from a study of male, female and castrated sheep reared under 'high' and 'low' plane nutrition and slaughtered at different ages from 6/7 months to 4 years 9 months (Popkin *et al.* 2012: supplementary material). The purpose is to determine whether sex, age and nutrition affect astragalus shape. Average values of the indexes are given [with sample size/standard deviation in square brackets]. 'CA' refers to the calcaneum, and the state of its fusion with the *tuber calcis*. When considering all these comparisons in combination, it appears that change with respect to sex, age and nutrition status is very small or non-existent and would not significantly affect the values of DI/GLI and Bd/DI when attempting to separate sheep from goat astragali. For example nutritional status clearly has no effect upon either index, sex has little or no effect upon the value of DI/GLI and only a very small effect upon Bd/DI and age only a small effect upon Bd/DI. Caution – the ages considered here range from 6/7 months to c. 4 years 9 months and 'High' and especially 'Low' nutrition could have been more extreme in antiquity.

Portugal/Spain (Fig. 9.2 bottom left)

Sheep (both of unknown breed and Merino) separate from goats (both of unknown breed and Serpentina). However, several of the modern Churra da Terra Quente sheep plot among the goats. These Churra sheep served as the University of Trás os Montes and Alto do Douro department of agriculture flock. They had been kept indoors on soft hay bedding *all* their life (Jorge Azevedo, pers. comm.) and so I suspect they can be ignored for the purposes of this study. It is likely that living conditions affect the shape of certain bones in the skeleton. One example of this is the so-called 'squatting facet' observed on the astragalus in people who habitually squat (Oygucu *et al.* 1998). On balance the majority of sheep and goat separate but there is some overlap between these two taxa. Again it should be noted that astragali of several of the wild goat (ibex) and feral goats from Mallorca overlap those of the sheep.

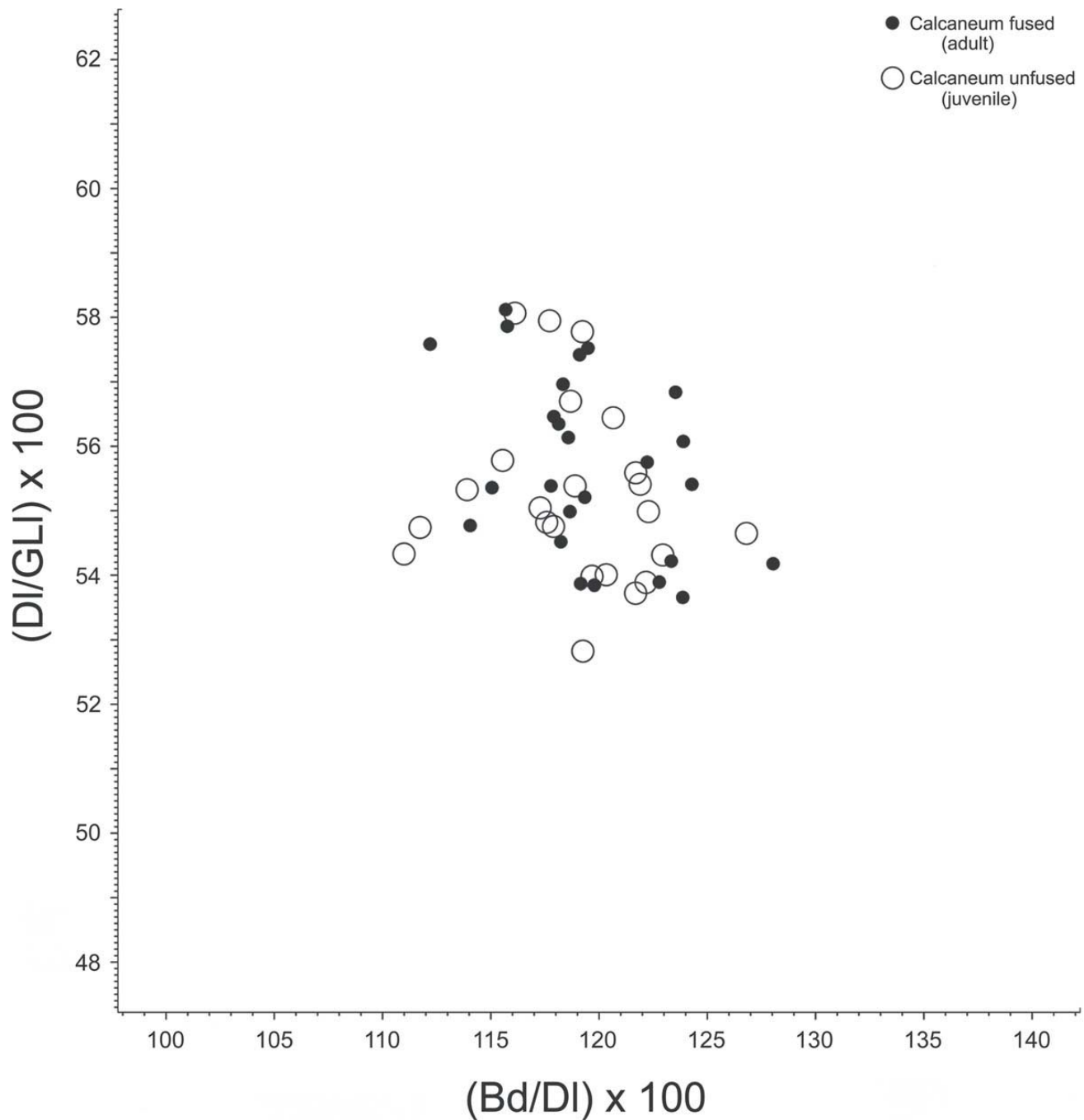


Fig. 9.1. The effect of age upon the two indexes used here to separate sheep from goat astragali. A plot of the same indexes as in Figs 9.2–9.3 for modern Merino sheep from southern Portugal to show the slight but insignificant (for the purposes of separating sheep from goat) difference with age. The juvenile merinos whose tuber calcis had not fused to the calcaneum had been slaughtered around 7–8 months. The ‘y’ and ‘x’ axes are the same as in the other figures.

Paros, Greece (Fig. 9.2 bottom right)

A collection of modern sheep and goat astragali from this island in the Cyclades shows a reasonable separation of sheep from goat. Note that like the modern caprines from the Iberian Peninsula and Britain, the index Bd/DI fails to provide much, if any, separation.

Iran and Iraq

These indexes for 31 wild sheep and wild goat astragali in the Field Museum, Chicago overlap by too great an extent and so this metrical method probably cannot be used for wild sheep and wild goat in this region. (This failure to separate for the wild sheep and wild goats was already hinted at in Fig. 9.2 top right.) However, the specimens derive from a wide geographical range – from Azerbaijan to Baluchistan and from Khorasan to Fars. More specimens are needed from each of these regions to control for possible geographical variation. Why the astragali of the wild taxa fail to discriminate but the domesticated ones do, is unclear and difficult to explain. It is of course possible that one or both of these wild forms are not related to the domestic caprines considered here. For example, were the domestic sheep we are separating from the domestic goats in the archaeological and modern samples here all derived from a population(s) of wild sheep with a different morphology from those in Iran/Armenia?

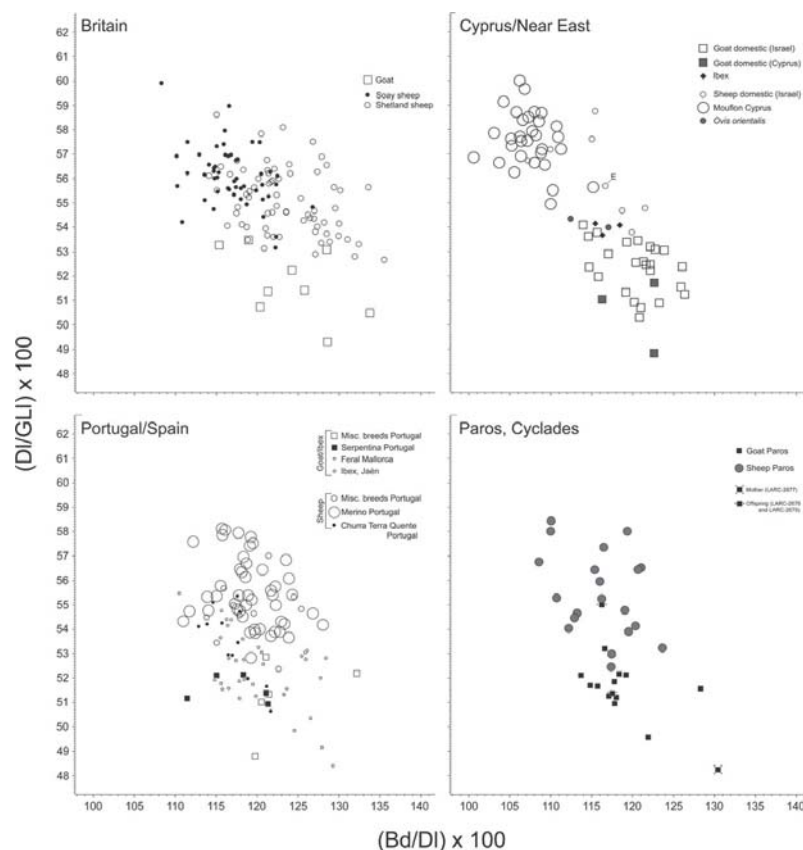


Fig. 9.2. Scatter diagrams of two indexes, DI/GLI and Bd/DI calculated from the three measurements taken on astragali of modern sheep and goat from four geographical regions today shown in clockwise order from the top left: Britain, Cyprus and the Near East, Paros island (Cyclades, Greece) and Portugal and Spain (including ibex from Jaén province, Spain and feral goats from Mallorca) to show the separation between *Ovis* and *Capra*. Note that there appears to be reasonable distinction between species although perhaps rather more overlap than in the Neolithic caprines from Cyprus shown in Fig. 9.3. Some of the Portuguese Churra da Terra Quente sheep overlap considerably with the goats but since they were kept under abnormal living conditions they can probably be ignored. Unimproved Shetland sheep measurements are in Davis (1996; 2000). Among the Paros goats, one (marked with four asterisks) was the mother of two siblings (marked with two asterisks).

Table 9.3. Variation of the shape – Bd/Dl – of sheep astragali through time and between breeds. Bd/Dl is the index shown on the ‘x’ axis of the graphs

Locality	Breed/ site	Period	n	Astragalus index (Bd/Dl) $\times$ 100
Britain	Shetland	modern	68	124
	Soay	modern	53	117
Portugal	Merino	modern	48	119
	Beja	15th cent. AD	34	119
	Silves+Santarém	Moslem	35	115
	Torre Palma+Santarém	Roman	29	116
	Santarém	Iron	11	116
	Zambujal+Leceia	Chalcolithic	85	112
	Lameiras	Neolithic	21	114
Israel	Domestic	modern	5	116
Cyprus	Mouflon	modern	31	107
	Khirokitia: all periods	Neolithic*	817	110
	Khirokitia: late	Pottery Neolithic 2	16	109
	Khirokitia: mid-	Neolithic III-I	600	110
	Khirokitia: early	Neolithic H-B	111	111
	Shillourokambos	Neolithic**	19	114
Paros, Cyclades	Domestic	modern	19	116

* Note that the pooled data for Khirokitia include specimens from mixed layers.

** An outlier was removed from the Shillourokambos measurements in Vigne (2011).

Archaeological specimens first identified via Boessneck’s (1969) criteria

Cyprus – Khirokitia (Aceramic Neolithic; Fig. 9.3)

It is this archaeological sample from Cyprus that shows the best separation between sheep and goat, with each index providing some distinction. Hence the combination of both indexes improves separation, leaving a guesstimated 5–10% overlap. Sheep appear to have greater values for Dl compared to GLl and goats have greater values for Bd compared to Dl . Put another way sheep have relatively deeper astragali and goats relatively wider ones. It is interesting that the modern mouflon astragali (see Table 9.3 and Fig. 9.2) have very slightly smaller index Bd/Dl – they are more slender – than the Khirokitia specimens. Are the Neolithic *Ovis* still somewhat robust like their wild ancestors and over time on the island wild *Ovis* (mouflon) have ‘degenerated’ and become slenderer – perhaps partly due to reduced or absent predator pressure? [In the course of my studies of the Khirokitia bones between 1981 and 2007, approximately 12 of the 894 sheep and goat astragali plotted out in the ‘wrong’ cloud of dispersion. Subsequently, these were retrieved and re-studied and indeed most proved to have been erroneously identified.]

Britain (Fig. 9.2)

At Launceston Castle only one goat astragalus was identified among the 73 fully measurable caprine astragali (see table 42 in Albarella and Davis 1996). This single goat, while not clearly separate from the sheep, does at least plot towards the lower right-hand side of the dispersion. Unfortunately goats are extremely scarce in English archaeological sites.

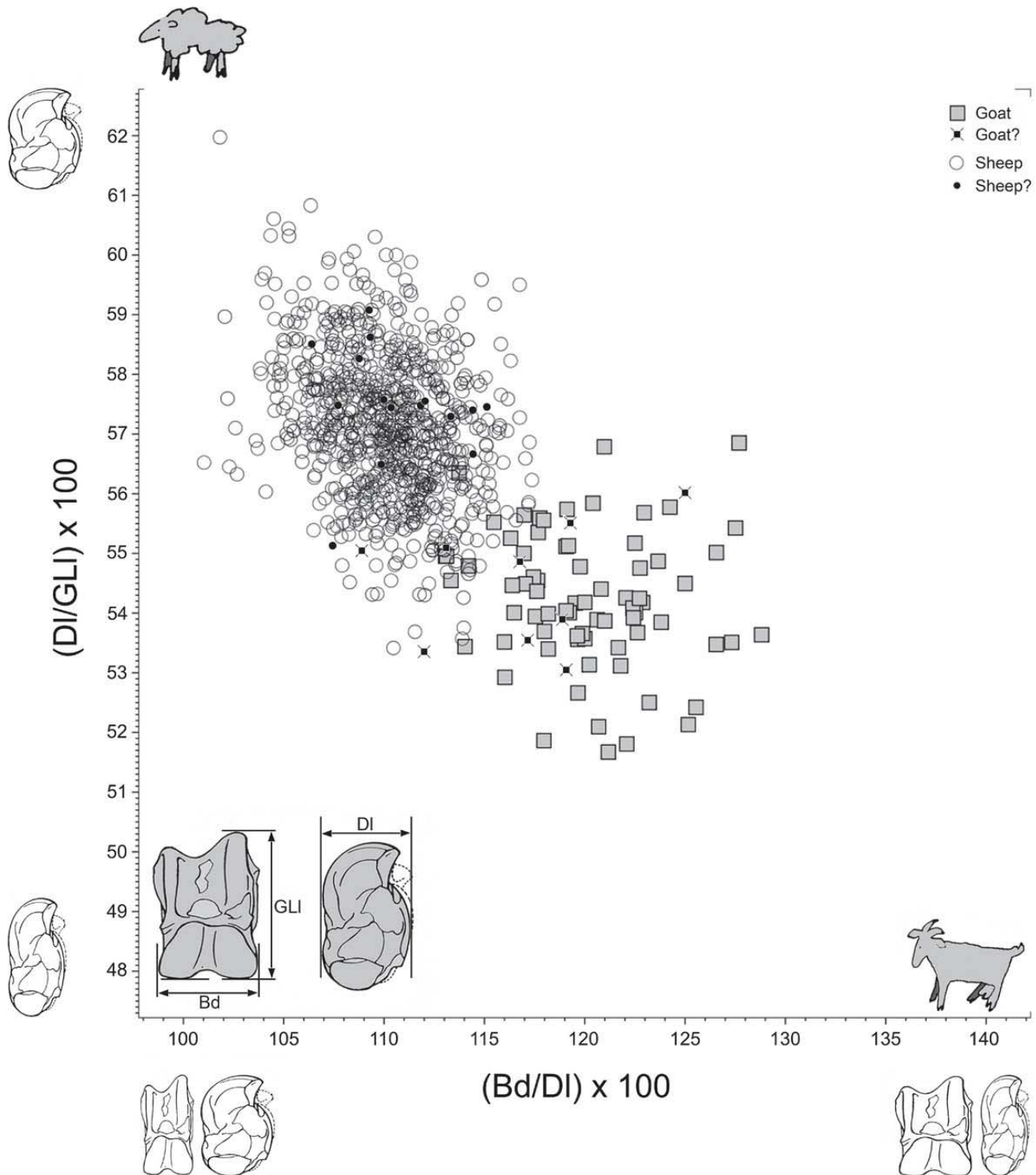


Fig. 9.3. A scatter diagram of two indexes, DI/GLI and Bd/DI calculated from the three measurements taken on 894 caprine astragali identified via Boessneck's morphological descriptions from the Neolithic site of Khirokitia, Cyprus. Goats are represented by squares and sheep by circles with less securely identified specimens being shown as smaller black symbols. Note the reasonable separation between the two taxa with most goats plotting towards the bottom right and sheep towards the top left side of the graph. There is a guesstimated 5–10% overlap which means that an individual specimen cannot be identified with 100% confidence! On the periphery are exaggerated sketches of what the differently shaped astragali look like. Thus the sheep have a relatively deep bodied astragalus perhaps correlated with their relatively (to goat) long metatarsal and the goats have a relatively wider astragalus as do their distal metapodials – this may be the width that provides these animals with better control and balance while negotiating the typically rocky nature of their environment.

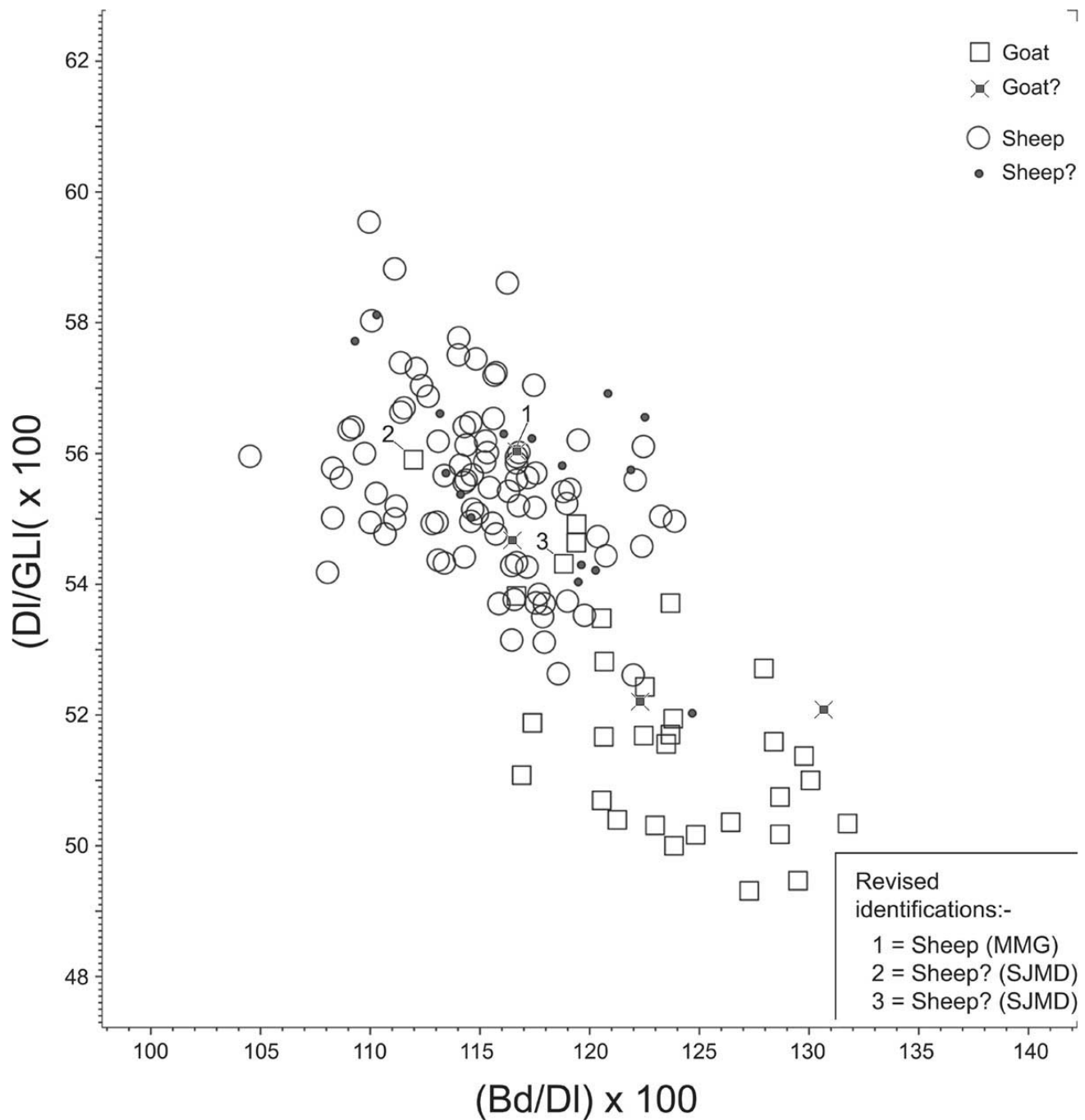


Fig. 9.4. Scatter diagram of DI/GLI against Bd/DI for caprine astragali identified by me from four archaeological sites in Portugal to determine if the method works and/or to highlight my ability/inability to identify sheep and goat astragali. The sites are Lameiras (Neolithic), Alcaçova de Santarém (Iron Age–Moslem), Castro Marim (Iron Age–Roman) and Silves (Almohad Moslem) – all situated in the southern half of Portugal. According to the osteometry either I have miss-identified 5 or 6 sheep astragali as goat, and 1 or 3 goat astragali as sheep or ancient Portuguese sheep and goat astragali showed considerably more overlap in their shape than they do today (compare with Fig. 9.2). The ‘Goat?’ labelled ‘1’ was identified by an erstwhile colleague as sheep, and the two astragali identified as ‘Goat’, labelled ‘2’ and ‘3’, were also re-examined by me and on morphological grounds are more likely to be sheep. This suggests that my own identifications were in error. I have not been able to re-examine the other 2 or 3 astragali identified as ‘goat’ that plot among the sheep but these may also have been erroneously identified.

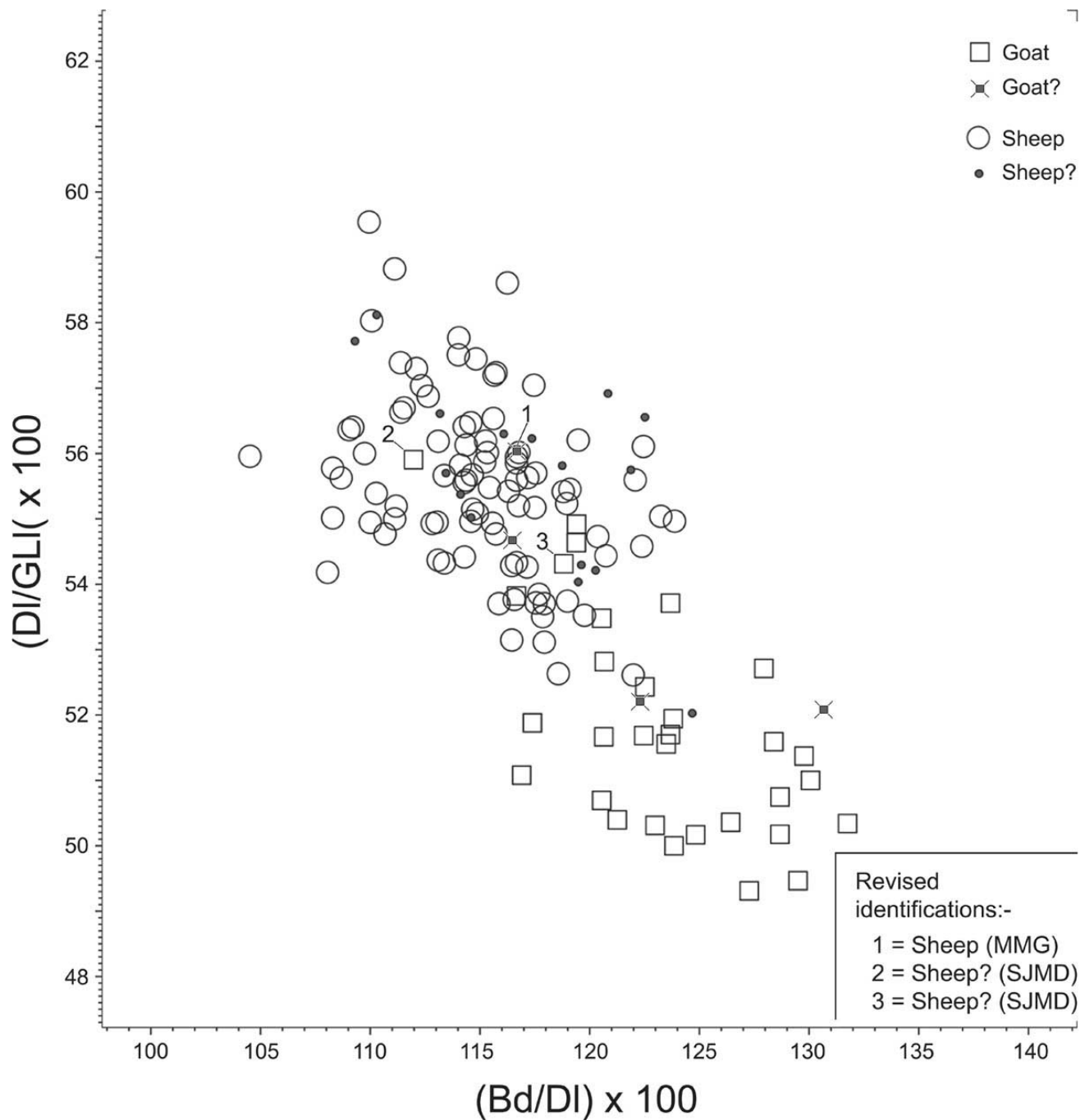


Fig. 9.5. Scatter diagram of DI/GLI against Bd/DI for caprine astragali identified by me from the Bronze Age to Roman site Tel Yarmout in Israel to determine if the method works and/or to highlight my ability/inability to identify sheep and goat astragali. The majority of the animal bones from this site derive from the Early Bronze Age levels. Note that four astragali were initially identified by me as goat – these all plot well within the sheep region. I have been able to retrieve and re-study three of these and they appear to have been originally misidentified. One is sheep/goat and two are probable sheep.

Portugal (Fig. 9.4)

Figure 9.4 combines measurements of caprine astragali from four archaeological sites ranging in date from the Neolithic to the Moslem period. The majority of these Portuguese sheep and goat astragali appear to plot out in the same way as those from Cyprus, with the sheep towards the top left and goats to the bottom right, although again there is some overlap. Note there are several specimens that I

identified as goat that plot quite clearly among the sheep. I have managed to retrieve or re-consider three of these and they are labelled with small numbers on the graph. Thus my 'goat?' number '1' has been identified by a colleague as sheep. I have also re-examined 'goat's numbered '2' and '3', and indeed they are certainly not definite goat and I would now identify them as 'sheep?' Three or four other astragali identified as belonging to goat fall among the sheep and were perhaps also misidentified.

Israel (Fig. 9.5)

Tel Yarmout is an Early Bronze Age to Roman site in central Israel. Animal remains from this predominantly Early Bronze Age site are being studied by me. All three measurements GLI, Bd and DI could be taken on 115 well conserved caprine astragali. When a graph (Fig. 9.5) of the two indexes proposed herein was plotted, the bulk of the 'sheep' and 'goat' separated out with a small area of overlap. Four 'goat' astragali fell among the sheep. I have re-examined three of these and indeed one is most probably 'sheep or goat' (marked with two asterisks) and two are 'probable sheep' (marked with four asterisks). The final tally of taxa is 69 sheep, 38 goats and eight sheep/goats. All the last fall among the sheep and so probably belonged to sheep.

What do these graphs show?

A functional aspect

Of the two indexes considered herein, that which provides the better distinction between sheep (higher values) and goat (lower values) is the lateral depth (DI) divided by the greatest lateral length (GLI). In other words sheep astragali are relatively *deeper* than those of goats. Why should this be? One point worth remembering is that in general measurements of sheep bones taken along the same axis are more highly correlated with one another than measurements taken along different axes. Thus lengths of limb bones show a higher correlation than do lengths with widths (Davis 1996). Is the lateral depth, DI, of the astragalus another length measurement? The answer to this question would seem to be yes, for if we compare the correlation coefficients of the three astragalus measurements considered in this study with various limb-bone lengths as in Table 9.4 (data from Davis, 1996), we see that the correlation values for DI are higher than those for GLI and for Bd. In other words astragalus DI is behaving like a measure of 'limb-length'. This seems logical when one views the position within the ankle of the astragalus, articulated between the distal tibia and the more distal tarsal bones and metatarsal. The axis of the hind-limb length runs at an angle to the dimension DI. Hence we are in effect seeing sheep with their longer limb bones (especially metatarsals adapted to running) having this same greater gracility reflected in the astragalus. This is not really apparent when we examine an isolated astragalus. It is always important to remember that bones articulate with one another and so should be considered as parts of a functioning unit.

Table 9.4. Correlation coefficients of astragalus lateral depth (DI) with various limb-bone lengths for a flock of 26 adult unimproved Shetland ewes (Davis 1996, table 7)

	<i>Humerus</i>	<i>M'carpal</i>	<i>Femur</i>	<i>Tibia</i>	<i>M'tarsal</i>
GLC	GL	GLC	GL	GL	
Astragalus-DI	0.77	0.79	0.64	0.67	0.77
Astragalus-GLI0	0.69	0.70	0.58	0.64	0.66
Astragalus-Bd	0.70	0.71	0.63	0.66	0.68

Compare the rather higher values for DI and lower ones for GLI and Bd. This indicates that limb-length is more closely related to the lateral depth of the astragalus than the other two astragalus dimensions and may explain why astragalus-DI tends to discriminate between sheep astragali and goat astragali better than the other two dimensions. The sheep is more cursorial and therefore has longer limbs.

Chronological and breed differences

When we compare the results for Cyprus with those from other regions, there is an interesting but enigmatic difference. While for the Cypriot Neolithic, and archaeological Portuguese caprines, both indexes – DI/GLI and Bd/DI – seem to equally and partially separate sheep from goat. In present-day Portugal and Britain and perhaps Paros too, only DI/GLI provides separation with the index Bd/DI failing to separate sheep from goat. Careful comparison of the plots shows that the goats always plot out in the same region of the graph. However it is the sheep that vary both in the course of time and when we compare a ‘primitive’ breed like the Soay with a more ‘modern’ one like the Shetland. Thus the more ancient sheep are situated in the top left hand side of the graph, while the more ‘modern’ ones appear to have shifted across towards the right, i.e., they have become skeletally more robust.

Archaeological remains of sheep from Portugal hint towards *increasing* robustness with time. The difference between the Neolithic sheep at Lameiras (Davis *et al.* in prep.) and modern merinos (the indexes for black and white merinos are pooled as they are similar) indicates increasing robustness from 114 to 119 (Table 9.3). Thus while the Neolithic sheep have an average Bd/DI value of 114, the Chalcolithic sheep have an average value of 112 and fifteenth century AD and modern merinos have an index of 119. Samples from Iron Age, Roman and Moslem periods are intermediate. And similarly compare the modern Soay, a very ancient relict breed, with modern unimproved Shetland sheep. They show an increase in robustness from 117 to 124.

A chronological succession on the island of Cyprus appears to show the opposite trend (Table 9.3) where the index Bd/DI *decreases* with time – thus as we progress from the earliest sample of sheep from Aceramic Neolithic Shillourokambos (Vigne 2011) with a value of 114, that for the later Aceramic Neolithic site of Khirokitia is 110 and modern mouflon have an index of 107. As one can see in Table 9.3, this trend is apparent even within the Khirokitia succession from the oldest layers H-B to the younger layers III-I and on to the overlying layer 2.

The meaning of these changes is unclear but could reflect the use to which these different populations/breeds of sheep were/are put – meat or secondary products. The sheep is an animal that

has probably undergone considerable selection, especially since medieval times, for better wool, more milk and heavier carcass size. Are we witnessing in Britain and Portugal the result of selection, in the course of time, for sheep with wider bones to support the larger carcass weight?

Although this study includes too few goats to be sure, the graphs do hint at a relative stability of goats both through time and between different localities. Can we say that the goat, the poor man's sheep, has been less subjected to forces of artificial selection? This apparent shape change in sheep, but not goat, astragali may be worth further investigation.

Conclusions

A plot of astragalus DI/GLI against Bd/DI provides a reasonably good method for distinguishing sheep from goat in many regions, especially Cyprus. Unfortunately the small collections of measurements of wild *Ovis* and wild *Capra* both in the Iberian Peninsula and in the Near East indicate that this method may not work so well or at all for these wild taxa. While clearly more samples are needed, this method may well prove a useful aid in separating, or part-separating, domestic sheep from domestic goat astragali – especially given the tendency for astragali to be well preserved on archaeological sites. Boessneck's morphological criteria should, however, be used in combination with this metrical method as it is dangerous to rely solely upon measurements. The small shape differences both between breeds and through time shown by the sheep but perhaps not by the goats may reflect the more intense and varied selection pressures that have been exerted upon sheep but not goats. The strange result obtained for the Churra sheep kept indoors may be worth further study and perhaps reflects their lifestyle. Moreover given the substantial amount of geographical variation, especially of the sheep, it is important to use local reference bones of the animals when trying to identify archaeological specimens and also to keep an open mind to the possibility of chronological changes. Domestic sheep and goat astragali, as shown in this study, appear to obey Cuvier's (1812) *loi de correlation des formes* in the majority of cases. It is to be hoped that this metrical method will be tested on other collections of caprine astragali.

Acknowledgements

I thank Peter Rowley-Conwy for inviting me to contribute to this volume in memory of Tony Legge – friend and colleague whom I first met in Jerusalem in 1971. I always enjoyed Tony's company and appreciated his frankness as well as his respect for, and knowledge of, the early writers on animal husbandry and zoology. I am also personally indebted to Tony for finding me employment as an extra-mural teacher in London evening schools – a most rewarding experience. This small study is a spin-off from 30 years' involvement with the excavations at Khirokitia in Cyprus directed by Alain Le Brun and Odile Daune-Le Brun. I have benefitted from their hospitality as well as that of the inhabitants of present-day Khirokitia. Many people have been most generous in supplying skeletons or partial skeletons of sheep and goat: I am grateful to Yorgos Nicoletti for goats, officers of the forest station at Stavros tis Psokas for mouflons, Alex Valenzuela and Josip Alcover for feral goats from La Trapa, Mallorca, António Abel and Alfredo Sendim of Freixo do Meio, Montemor-o-Novo for merinos, Jorge Azevedo, Ana Luísa Lourenço and students of UTAD, Vila Real for churra da terra quente sheep, Miguel Madeira of Beja for merinos, Nelson Pereira, Senhor Fernando of 'Talho Verde' in Lisbon and Yiorgos Loukis of 'To Kamari' in Alyki, Paros for a constant supply of various sheep and goats. I also thank Eleftherios Hadjisterkotis for providing me access to his collection of mouflon skeletons. Guy Bar-Oz loaned me all his modern caprine astragali from the Haifa University zooarchaeology reference

collection and Polydora Baker spent considerable time measuring modern Soay sheep and assorted British goat astragali in the English Heritage ‘Centre for Archaeology’ collections. Rebecca Banasiak measured astragali of the wild sheep and goats from Iran and Iraq housed in the Field Museum of Natural History, Chicago. The Spanish ibex were measured while in receipt of a grant from ‘Synthesis’ at the Museo Nacional de Ciencias Naturales, Madrid. Simone Scaraffiotti was a great help to me in Paros and her hospitality is gratefully acknowledged. I have also benefitted from a useful exchange of ideas with David Gonçalves, John Watson and Umberto Albarella. Albarella also offered useful comments on an earlier draft of this article.

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Appendix 9.1

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
11504	CAH	A	337	223	182
5165	CAH	B	304	199	169
4416	CAH	B	315	202	172
5943	CAH	B	320	195	171
5793	CAH	B	320	207	168
12945	CAH	B	323	206	176
12263	CAH	B	328	211	176
5701	CAH	B	330	204	180
12657	CAH	B	334	209	183
5255	CAH	B	337	218	179
12250	CAH	B	351	236	196
5103	CAH	B	355	246	198
12263	CAH	B	359	231	194
3366	CAH	B	374	240	204
5881	CAH	B	381	248	212
13410	CAH	C	290	196	160
13001	CAH	C	309	195	165
7313	CAH	C	329	206	170
13002	CAH	C	335	214	178
12993	CAH	C	338	213	178
3716	CAH	C	342	210	181
7951	CAH	C	342	233	183
3820	CAH	C	352	241	196
8113	CAH	C	354	233	190
13446	CAH	D	306	202	165
11207	CAH	D	332	210	172
11207	CAH	D	334	210	174
4087	CAH	D	352	231	194
3354	CAH	D	376	249	204
10726	CAH	E	318	209	173
13510	CAH	E	365	243	198
13698	CAH	F	300	193	165
14139	CAH	F	305	205	167
13920	CAH	F	326	208	176
14270	CAH	F	337	212	182
14328	CAH	F	355	227	193
14145	CAH	F	361	248	205
14295	CAH	F	404	251	222
14479	CAH	G	331	224	177
14333	CAH	G	333	207	183
14495	CAH	G	336	213	183
14479	CAH	G	349	243	192
14523	CAH	G	351	230	195

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
14494	CAH	G	352	223	189
14544	CAH	H	333	214	184
6574	CAH	II	312	202	169
10699	CAH	II	312	205	172
6206	CAH	II	322	197	167
7742	CAH	II	327	213	181
6432	CAH	II	330	228	177
11128	CAH	II	336	219	181
6731	CAH	II	339	230	186
6457	CAH	II	341	241	189
10729	CAH	II	343	249	195
10963	CAH	II	351	231	184
6574	CAH	II	360	234	194
10494	CAH	II	366	243	204
10862	CAH	II	371	247	201
11128	CAH	II	380	247	203
11640	CAH	III	305	199	159
7545	CAH	III	323	207	173
11662	CAH	III	337	217	182
11670	CAH	III	355	235	192
50880	CAH	P	304	195	163
50764	CAH	P	312	208	168
50466	CAH	P	314	206	172
50363	CAH	P	317	201	171
51132	CAH	P	323	210	175
50616	CAH	P	326	209	181
50037	CAH	P	364	234	195
50353	CAH	P	367	250	200
8236	CAH?	C	334	208	184

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
10242	OVA	2	321	210	190
10242	OVA	2	325	203	190
10255	OVA	2	327	214	192
10242	OVA	2	328	197	186
10188	OVA	2	329	207	185
9373	OVA	2	334	197	185
9371	OVA	2	338	214	195
10350	OVA	2	346	216	198
7823	OVA	2	352	225	206
9330	OVA	2	357	217	200
12056	OVA	A	304	187	178
12181	OVA	A	306	186	172
12022	OVA	A	306	187	173
12117	OVA	A	306	189	176
12224	OVA	A	308	194	176
11532	OVA	A	309	187	173
12155	OVA	A	310	191	179
12163	OVA	A	310	191	179
12044	OVA	A	311	196	178
12124	OVA	A	316	193	184
12056	OVA	A	316	200	183
12130	OVA	A	317	201	181
11519	OVA	A	320	198	183
12118	OVA	A	322	192	178
6525	OVA	A	324	206	187
11543	OVA	A	324	208	194
11586	OVA	A	325	210	189
12169	OVA	A	325	214	188
11707	OVA	A	328	203	182

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
11971	OVA	B	292	189	164
12685	OVA	B	293	184	172
12293	OVA	B	294	186	167
12663	OVA	B	295	186	163
5910	OVA	B	296	180	166
4605	OVA	B	296	191	172
12736	OVA	B	298	197	177
5085	OVA	B	300	190	171
11922	OVA	B	302	193	172
4197	OVA	B	302	200	176
12533	OVA	B	303	198	179
12764	OVA	B	304	194	175
12489	OVA	B	305	201	174
3678	OVA	B	307	190	169
5233	OVA	B	307	192	168
6659	OVA	B	307	197	176
12456	OVA	B	308	190	179
5438	OVA	B	308	192	174
5543	OVA	B	308	198	177
12448	OVA	B	308	202	176
12748	OVA	B	308	202	179
6621	OVA	B	309	192	180
5597	OVA	B	309	199	180
6388	OVA	B	310	179	175
12673	OVA	B	310	193	178
12678	OVA	B	311	206	176
7213	OVA	B	312	194	181
12290	OVA	B	312	196	176
12924	OVA	B	313	197	176

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
5059	OVA	B	322	201	180
12456	OVA	B	322	211	182
5811	OVA	B	325	206	189
3466	OVA	B	325	209	185
5378	OVA	B	325	211	186
12736	OVA	B	326	203	182
9409	OVA	B	327	203	186
5225	OVA	B	328	207	189
12293	OVA	B	330	205	197
4633	OVA	B	330	206	186
12683	OVA	B	331	212	187
12680	OVA	B	332	205	190
5813	OVA	B	332	211	194
3645	OVA	B	333	196	189
4296	OVA	B	333	212	196
5437	OVA	B	336	211	193
4580	OVA	B	336	212	198
5539	OVA	B	336	216	191
12584	OVA	B	337	213	187
3874	OVA	B	339	216	194
12293	OVA	B	339	220	191
5235	OVA	B	341	212	194
5795	OVA	B	341	222	197
12249	OVA	B	342	212	193
5137	OVA	B	345	217	192
8415	OVA	C	291	188	166
9284	OVA	C	297	190	174
13183	OVA	C	298	194	174
13008	OVA	C	306	191	171

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
7952	OVA	C	331	201	188
7555	OVA	C	338	206	188
3765	OVA	C	339	223	197
4687	OVA	C	340	213	197
8561	OVA	D	286	182	164
3648	OVA	D	308	192	169
13109	OVA	D	309	193	175
8493	OVA	D	311	200	183
8569	OVA	D	312	203	182
13627	OVA	D	316	214	184
10251	OVA	D	323	204	184
8560	OVA	D	330	207	186
6705	OVA	E	288	185	168
5319	OVA	E	303	184	176
3457	OVA	E	303	190	171
5669	OVA	E	304	190	173
10726	OVA	E	311	203	176
4813	OVA	E	352	220	201
13824	OVA	F	363	226	199
14448	OVA	G	322	207	193
9170	OVA	I	297	188	164
9269	OVA	I	301	185	172
8975	OVA	I	303	186	170
9028	OVA	I	304	182	170
6399	OVA	I	306	204	174
8969	OVA	I	307	190	171
9366	OVA	I	307	195	174
8794	OVA	I	307	203	178
9609	OVA	I	308	194	173

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
9590	OVA	I	322	196	180
8840	OVA	I	322	204	184
9354	OVA	I	323	206	185
8814	OVA	I	323	207	188
9391	OVA	I	324	197	185
9319	OVA	I	324	213	187
9135	OVA	I	325	211	188
9562	OVA	I	326	204	180
9590	OVA	I	326	206	182
9627	OVA	I	326	216	186
8971	OVA	I	328	205	186
6458	OVA	I	329	202	185
9028	OVA	I	329	218	193
9563	OVA	I	330	202	184
9338	OVA	I	330	212	195
9300	OVA	I	331	212	185
8975	OVA	I	332	214	186
9610	OVA	I	333	203	186
9261	OVA	I	333	203	190
9563	OVA	I	333	209	193
9063	OVA	I	336	200	191
9610	OVA	I	337	215	199
6458	OVA	I	339	211	187
9366	OVA	I	339	232	202
8768	OVA	I	340	212	192
9357	OVA	I	340	215	201
10274	OVA	I	345	228	197
9230	OVA	I	349	218	197
9546	OVA	I	350	211	201

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
6731	OVA	II	300	194	171
6330	OVA	II	300	195	172
6747	OVA	II	300	195	175
7262	OVA	II	300	198	177
6432	OVA	II	303	185	173
10439	OVA	II	303	196	173
10305	OVA	II	303	198	177
10323	OVA	II	303	200	180
10738	OVA	II	304	187	170
10384	OVA	II	304	193	178
6429	OVA	II	304	194	176
9999	OVA	II	304	198	176
10608	OVA	II	305	187	176
10903	OVA	II	305	196	176
10351	OVA	II	305	197	173
10321	OVA	II	305	199	175
11128	OVA	II	306	190	175
10150	OVA	II	306	194	180
6429	OVA	II	306	198	179
9788	OVA	II	307	184	175
10729	OVA	II	307	191	169
9999	OVA	II	307	191	177
6733	OVA	II	307	191	178
10718	OVA	II	307	199	184
10386	OVA	II	307	205	177
10734	OVA	II	308	193	172
6562	OVA	II	308	194	178
10294	OVA	II	308	195	178
6471	OVA	II	308	201	178

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
10385	OVA	II	310	196	174
6216	OVA	II	310	198	183
10741	OVA	II	311	193	179
7332	OVA	II	311	193	181
6396	OVA	II	311	197	179
9699	OVA	II	311	202	181
10734	OVA	II	311	205	178
11380	OVA	II	312	188	181
9999	OVA	II	312	191	173
10517	OVA	II	312	192	177
6563	OVA	II	312	194	176
10737	OVA	II	312	197	175
6733	OVA	II	312	198	176
10218	OVA	II	312	198	176
10731	OVA	II	313	186	170
9788	OVA	II	313	189	174
10518	OVA	II	313	190	170
10722	OVA	II	313	195	177
10294	OVA	II	313	195	181
9787	OVA	II	314	193	174
6207	OVA	II	314	195	175
10963	OVA	II	314	197	179
6547	OVA	II	314	198	175
9890	OVA	II	314	198	182
9687	OVA	II	314	199	178
6669	OVA	II	315	190	183
9787	OVA	II	315	194	183
10377	OVA	II	315	195	182
11227	OVA	II	315	196	176

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
10508	OVA	II	316	205	183
10340	OVA	II	316	206	179
10194	OVA	II	316	216	187
10670	OVA	II	317	189	177
10670	OVA	II	317	190	176
9750	OVA	II	317	196	172
9787	OVA	II	317	196	183
10169	OVA	II	317	198	180
6246	OVA	II	317	202	178
6807	OVA	II	317	202	180
11228	OVA	II	317	203	178
10426	OVA	II	317	205	181
9715	OVA	II	317	205	184
10218	OVA	II	317	211	186
7399	OVA	II	317	212	187
10151	OVA	II	318	194	181
6547	OVA	II	318	196	183
10286	OVA	II	318	198	179
10718	OVA	II	318	200	182
10827	OVA	II	318	200	182
10169	OVA	II	318	203	179
11610	OVA	II	318	203	182
10888	OVA	II	318	210	190
6652	OVA	II	319	192	174
10850	OVA	II	319	192	182
10529	OVA	II	319	192	182
10608	OVA	II	319	194	185
9788	OVA	II	319	195	180
9803	OVA	II	319	199	182

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
9903	OVA	II	321	202	183
7743	OVA	II	321	202	188
10331	OVA	II	321	203	185
6652	OVA	II	321	204	181
10495	OVA	II	321	204	183
6731	OVA	II	321	204	184
10495	OVA	II	321	207	182
10166	OVA	II	321	214	186
10729	OVA	II	321	223	191
6731	OVA	II	322	196	177
10614	OVA	II	322	198	181
10699	OVA	II	322	198	186
10294	OVA	II	322	200	180
6442	OVA	II	322	200	182
10169	OVA	II	322	200	186
11615	OVA	II	322	201	176
6457	OVA	II	322	201	179
10738	OVA	II	322	201	180
11128	OVA	II	322	201	181
10734	OVA	II	322	202	182
10731	OVA	II	322	204	185
9889	OVA	II	322	206	183
10383	OVA	II	322	207	182
10364	OVA	II	322	213	184
10718	OVA	II	323	191	177
10546	OVA	II	323	194	177
10613	OVA	II	323	199	181
10862	OVA	II	323	199	183
10174	OVA	II	323	200	178

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
10613	OVA	II	324	197	180
10434	OVA	II	324	198	182
10517	OVA	II	324	206	188
10577	OVA	II	324	208	187
10124	OVA	II	324	208	188
10123	OVA	II	324	210	188
10517	OVA	II	324	211	187
9803	OVA	II	324	212	185
10734	OVA	II	325	195	183
9750	OVA	II	325	197	184
10302	OVA	II	325	199	181
6585	OVA	II	325	199	184
10297	OVA	II	325	201	186
6563	OVA	II	325	202	179
10674	OVA	II	325	202	182
10608	OVA	II	325	202	188
6585	OVA	II	325	203	179
10004	OVA	II	325	204	186
11380	OVA	II	325	204	187
6205	OVA	II	325	204	190
10862	OVA	II	325	206	190
6807	OVA	II	325	206	190
10912	OVA	II	325	212	190
6517	OVA	II	325	214	188
10827	OVA	II	325	216	190
9715	OVA	II	326	194	181
10674	OVA	II	326	198	184
10218	OVA	II	326	198	189
6457	OVA	II	326	200	181

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
10741	OVA	II	327	209	185
6231	OVA	II	327	210	189
9903	OVA	II	327	216	194
10963	OVA	II	328	197	182
10654	OVA	II	328	198	182
6708	OVA	II	328	200	189
6488	OVA	II	328	201	182
11095	OVA	II	328	202	188
11206	OVA	II	328	205	185
6754	OVA	II	328	206	185
6798	OVA	II	328	207	186
10732	OVA	II	328	207	188
6341	OVA	II	328	208	186
10517	OVA	II	328	208	189
10717	OVA	II	328	210	188
10684	OVA	II	328	210	193
10674	OVA	II	328	211	187
6212	OVA	II	328	211	189
10384	OVA	II	328	212	191
10108	OVA	II	328	213	195
6209	OVA	II	329	197	182
6457	OVA	II	329	198	188
11095	OVA	II	329	198	194
10468	OVA	II	329	204	183
6949	OVA	II	329	204	192
10730	OVA	II	329	207	187
6563	OVA	II	329	210	186
9865	OVA	II	329	210	190
10354	OVA	II	329	213	186

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
10218	OVA	II	330	218	199
10732	OVA	II	330	219	191
9903	OVA	II	330	219	198
6683	OVA	II	331	202	187
10912	OVA	II	331	203	186
10884	OVA	II	331	206	183
6268	OVA	II	331	206	197
6457	OVA	II	331	207	193
10613	OVA	II	331	211	190
6731	OVA	II	331	212	187
10294	OVA	II	331	212	190
6547	OVA	II	331	212	191
9803	OVA	II	331	212	195
11077	OVA	II	331	214	197
6562	OVA	II	331	215	191
6652	OVA	II	331	215	196
10917	OVA	II	332	192	187
6432	OVA	II	332	196	181
6209	OVA	II	332	203	186
9888	OVA	II	332	204	183
6216	OVA	II	332	204	189
10003	OVA	II	332	204	190
10108	OVA	II	332	207	188
9715	OVA	II	332	209	189
10862	OVA	II	332	209	194
10674	OVA	II	332	211	190
10317	OVA	II	332	213	190
6766	OVA	II	332	213	195
10731	OVA	II	332	213	196

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
10742	OVA	II	334	214	191
11095	OVA	II	334	214	194
6747	OVA	II	334	214	195
6287	OVA	II	334	216	186
7332	OVA	II	334	218	198
6330	OVA	II	334	221	199
10732	OVA	II	335	202	193
6457	OVA	II	335	204	187
10732	OVA	II	335	206	188
6585	OVA	II	335	207	191
6547	OVA	II	335	208	187
11206	OVA	II	335	208	190
6731	OVA	II	335	211	188
10169	OVA	II	335	211	192
7399	OVA	II	335	211	194
6747	OVA	II	335	211	196
11231	OVA	II	335	211	197
10476	OVA	II	335	212	192
10718	OVA	II	335	212	195
10884	OVA	II	335	215	192
6206	OVA	II	335	215	196
10108	OVA	II	335	221	191
10718	OVA	II	335	227	196
10368	OVA	II	336	203	187
10742	OVA	II	336	204	186
11075	OVA	II	336	205	180
10347	OVA	II	336	205	188
6585	OVA	II	336	207	198
6374	OVA	II	336	208	185

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
6614	OVA	II	337	212	194
6207	OVA	II	337	214	193
10737	OVA	II	337	214	193
10718	OVA	II	337	215	192
10734	OVA	II	337	217	188
10494	OVA	II	337	220	198
11110	OVA	II	338	198	193
6550	OVA	II	338	204	187
6766	OVA	II	338	205	189
10714	OVA	II	338	207	190
10917	OVA	II	338	209	188
6563	OVA	II	338	210	194
11228	OVA	II	338	210	199
10912	OVA	II	338	214	191
7743	OVA	II	338	214	191
7023	OVA	II	338	221	192
6231	OVA	II	338	226	198
6628	OVA	II	338	226	198
10714	OVA	II	339	203	182
9989	OVA	II	339	203	193
10351	OVA	II	339	205	195
6907	OVA	II	339	207	186
10737	OVA	II	339	208	194
10220	OVA	II	339	209	195
9730	OVA	II	339	211	194
10621	OVA	II	339	212	187
11618	OVA	II	339	213	196
6457	OVA	II	339	216	192
10827	OVA	II	339	219	194

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
10535	OVA	II	341	207	191
11061	OVA	II	341	210	195
10321	OVA	II	341	215	192
10918	OVA	II	341	215	194
11618	OVA	II	341	218	197
10738	OVA	II	341	218	203
11128	OVA	II	341	219	192
9864	OVA	II	341	219	195
9787	OVA	II	341	221	198
10493	OVA	II	342	207	191
10583	OVA	II	342	207	195
6208	OVA	II	342	211	194
10183	OVA	II	342	215	192
9787	OVA	II	342	217	195
9865	OVA	II	342	220	199
10321	OVA	II	343	206	191
9687	OVA	II	343	207	192
10889	OVA	II	343	210	191
6741	OVA	II	343	210	194
10003	OVA	II	343	210	196
10218	OVA	II	343	211	190
9700	OVA	II	343	212	192
6807	OVA	II	343	216	198
10405	OVA	II	343	216	203
11399	OVA	II	343	219	195
10613	OVA	II	343	219	197
6807	OVA	II	343	220	195
10248	OVA	II	344	213	196
10674	OVA	II	344	213	205

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
11077	OVA	II	346	220	204
6797	OVA	II	347	214	195
10186	OVA	II	347	214	197
11077	OVA	II	347	216	193
10517	OVA	II	347	218	192
10731	OVA	II	347	219	198
10236	OVA	II	347	220	196
10196	OVA	II	348	203	195
10364	OVA	II	348	213	196
10517	OVA	II	348	216	201
9865	OVA	II	348	217	194
10351	OVA	II	348	217	197
6505	OVA	II	348	218	200
10577	OVA	II	348	219	199
10434	OVA	II	348	223	195
6721	OVA	II	349	220	201
10718	OVA	II	349	220	201
9787	OVA	II	349	221	199
9787	OVA	II	349	222	197
6534	OVA	II	349	227	201
10963	OVA	II	350	213	193
10646	OVA	II	350	213	204
10731	OVA	II	350	218	206
9814	OVA	II	350	220	202
10439	OVA	II	350	224	198
10717	OVA	II	350	228	206
10963	OVA	II	351	214	200
11287	OVA	II	352	213	200
10364	OVA	II	352	215	195

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
7421	OVA	II	371	228	212
10714	OVA	II	371	229	208
6443	OVA	II	374	230	216
7804	OVA	III	299	184	174
11651	OVA	III	299	185	166
11670	OVA	III	299	185	166
7675	OVA	III	300	188	169
7845	OVA	III	300	191	167
7717	OVA	III	301	196	174
7804	OVA	III	306	192	176
11383	OVA	III	306	193	176
7545	OVA	III	306	198	175
11674	OVA	III	309	189	175
7722	OVA	III	309	196	173
7814	OVA	III	312	189	171
7650	OVA	III	312	196	178
7440	OVA	III	312	204	179
7824	OVA	III	315	190	175
11662	OVA	III	316	207	181
7636	OVA	III	317	200	183
7737	OVA	III	319	201	181
11670	OVA	III	320	202	185
11674	OVA	III	321	194	184
11670	OVA	III	321	216	190
7510	OVA	III	324	196	184
7815	OVA	III	326	204	186
7440	OVA	III	327	196	184
11670	OVA	III	327	200	183
7353	OVA	III	328	213	188

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLI</i>	<i>BD</i>	<i>DI</i>
11256	OVA	III	344	216	195
11670	OVA	III	344	218	203
7845	OVA	III	345	212	196
11651	OVA	III	346	215	195
11670	OVA	III	348	218	202
6668	OVA	III	349	223	201
11653	OVA	III	353	223	199
6535	OVA	I-II	306	193	173
11683	OVA	I-II	309	196	180
6445	OVA	I-II	310	197	182
11685	OVA	I-II	313	202	183
11683	OVA	I-II	316	197	175
11678	OVA	I-II	324	201	184
11685	OVA	I-II	328	208	189
11685	OVA	I-II	334	210	183
11664	OVA	I-II	337	214	199
11683	OVA	I-II	340	210	195
11678	OVA	I-II	341	225	200
11685	OVA	I-II	345	197	195
11657	OVA	I-II	354	230	205
11263	OVA	I-II?	331	213	189
11263	OVA	I-II?	331	214	194
11263	OVA	I-II?	348	214	202
7825	OVA	I-III	308	190	174
7848	OVA	I-III	324	198	186
7852	OVA	I-III	326	202	192
7828	OVA	I-III	329	215	189
7825	OVA	I-III	330	203	187
7832	OVA	I-III	339	226	203

<i>Cat-No</i>	<i>Tax</i>	<i>Level</i>	<i>GLl</i>	<i>BD</i>	<i>Dl</i>
50757	OVA	P	332	211	193
50835	OVA	P	334	209	190
50108	OVA	P	336	213	191
50078	OVA	P	349	219	197
7857	OVA?	2	322	213	185
12702	OVA?	B	294	182	169
13224	OVA?	C	336	213	193
9382	OVA?	I	330	214	187
9382	OVA?	I	333	211	194
9382	OVA?	I	338	222	194
8850	OVA?	I	348	223	204
7836	OVA?	I-III	330	209	190
7837	OVA?	I-III	341	202	188
50873	OVA?	P	288	187	165
50870	OVA?	P	294	189	169
51044	OVA?	P	318	205	183

Measurements in tenths of a millimetre of the 814 well preserved and fully measurable sheep (OVA) and 80 goat (CAH) astragali from the Aceramic Neolithic site of Khirokitia in Cyprus that are plotted in Figure 9.3. These astragali had been identified by me using the morphological characters described by Boessneck *et al.* (1964) and Boessneck (1969). The columns are as follows:

Cat-No (the excavation unit); Taxon ('?' denotes specimens less securely identified to species); Level (the nine levels on the main site in the following chronological order from 'J' (oldest), to 'H', 'G', 'F', 'E', 'D', 'C', 'B', 'III', 'II', and 'I' the most recent. Level '2' is the overlying Ceramic Neolithic level. 'P' refers to a separate excavated area on the periphery of the main site which is probably contemporary with the earlier levels) and 'A' are specimens from levels 'III', 'II' and 'I'; GLl (greatest lateral length); Bd (distal width); Dl (depth measured down the lateral side).

Down among the dead men: wrong end epidemiology and its implications for palaeopathology

Tony Waldron

The principal aim of examining an assemblage of human remains is, surely, to reconstruct as far as possible the characteristics of the living population of which it was once a part, and it is understandable that those who attempt to do so should do their utmost to wring the last drop of information – aided where possible by ancillary investigations such as radiography or biochemistry, for example – from what are often pretty wretched specimens. To achieve this objective, however, it is necessary to employ suitable epidemiological methods but unfortunately a great many authors seem to forget this, basing their contentions on invalid speculations which lead at best to error and at worst, to wildly implausible conjectures.

The difficulty which is faced by those wishing to draw conclusions from an assemblage is that bone specialists are – epidemiologically speaking – almost always at the wrong end, as I will attempt to show in what follows. Modern epidemiologists generally start with a group of living individuals and although they may follow them through to death, or in some cases construct their population for study from the recently dead, it is always the *living* experiences of their subjects with which they are concerned. A typical study¹ might, for example, involve the recruitment of a group of subjects (often referred to as a cohort or more usually nowadays as the study-base) with exposure to some putative aetiological agent, or following some particular life-style, or indulging in habits such as smoking or drinking, and then following them up to see in how many the outcome variable of interest – a form of cancer or a lung disease, for example – develops compared with a non-exposed group. This design is referred to as a follow-up or cohort study and the most usual means of expressing the result of such a study is through the calculation of the relative risk which expresses the rate of the outcome variable in the exposed to that in the non-exposed control group.

In another common type of study, the so-called case-control (or case-referent) study, the procedure is the direct opposite of that described above; that is, individuals with the outcome variable are first identified and admitted into the study (the cases) together with another group who are without it, and who form the control or referent group. The exposure of both groups to the putative causative agent is then determined by some means or other – very frequently by the use of a questionnaire or interview – to see what proportion of each group has been exposed and from these proportions the odds ratio, rather than the relative risk as in a cohort study, is calculated. This can be seen by reference

to a simple 2×2 table (Table 10.1). The odds ratio in this case is: $(a/c)/(b/d) = ad/bc$, and the relative risk is: $(a/(a+b))/(c/(c+d))$.

In rare conditions, where a and c are very small compared with b and d , then it can readily be shown that the relative risk and the odds ratio are virtually the same.

Palaeopathologists, of course, do not have the luxury of access to the living and this imposes very severe restrictions on the types of study that they can carry out. It also precludes them from calculating all but one of the commonly used rates for expressing the frequency of disease in a population; those *not* available to them include the stillbirth rate, the neonatal mortality rate, and the infant mortality rate, all of which require to have the number of *live births* in the denominator which is, of course, unknowable. This is particularly unfortunate since knowledge of these rates would add greatly to our understanding of the conditions under which past populations lived and, especially, died. In fact the *only* measure of frequency of disease (or indeed of anything else) which can be calculated for an assemblage is the prevalence, which is simply the proportion of those with the disease (or condition) of interest. Since there is no time base, prevalence is not strictly a rate, although it is frequently referred to as the prevalence rate. In many papers, readers will see that reference is made to the *incidence* of disease, the term often being used as synonymously with prevalence. This is absolutely wrong, however, since incidence refers to the number of *new* cases that arise in a population over a certain time, a month or a year, for example. There is no way in which *new* cases can be ascertained for an assemblage and incidence should never be used in this context. (Calculating prevalence is not quite as simple as suggested here either since there are a number of different sorts of prevalence and for comparative purposes some summary statistic would need to be calculated to take into account the age and sex structure of the assemblages being compared. For further details see Waldron (2008a).

Table 10.1. *Difference between the odds ratio and the relative risk*

		Outcome variable		
		+	–	
Exposure	+	a	b	a + b
	–	c	d	c + d
		a + c	b + d	a + b + c + d

The fact that bone specialists are so poorly positioned has by no means always impaired their speculative powers and I will discuss two examples of wrong-end reasoning and one instance in which standing where we do is not necessarily an impediment.

Osteoarthritis and occupation

Osteoarthritis (OA) is by far the most common disease seen in human remains and in general it seems to have behaved in the past very much as it does today (Waldron 2008b). There are a number of

factors which are known to be important precipitants of OA, including age, sex, race, genetics, obesity, trauma and, most importantly, movement; if joints do not move, then (generally speaking) they do not develop OA. It is most important to remember that whatever the precipitant, or combination of precipitants, the appearances in the affected joint will be the same; OA of the thumb base, for example, does not vary in appearance no matter what the cause. The morphology of the lesion, therefore, gives no clue as to its aetiology.

It is very probable that it was the association with movement that first led to the idea that it would be possible to deduce the occupation of those whose skeletons showed evidence of OA. After all, in many occupations repetitive, stereotypical movements are part of the job and this might induce the development of OA in those genetically predisposed to do so. The notion does have a certain amount of face validity² and it is by no means only bone specialists who are interested in the connection, the clinical literature abounds with studies of OA in different occupational groups. Many studies have shown that some groups do indeed have a higher than expected frequency of OA in certain joints but there is no pattern of OA that is unique to any one group. Moreover there are many negative studies and by no means all those who engage in repetitive physical work develop OA while, conversely, many of those who work in entirely sedentary jobs, do. In other words, there is nothing clear cut about the relationship between work and joint disease in the living. (Two useful reviews of this subject are Felson (1994) and Cooper (1995)).

The most consistent relationship between occupation and OA has been shown to exist among farmers who have a relative risk of *c.* 9 for developing OA of the hip, irrespective of the type of farming in which they are engaged. Before assuming that a skeleton with OA of the hip must have come from a farmer, however, it is important to remember that those who are not farmers also get OA of the hip and, in fact, they are in a considerable majority.

A modern epidemiological study to examine the relationship between occupation and OA might typically identify a group of workers engaged in some physical activity or other, ascertain how many had OA and the joints that were affected, either from examination, or from medical records and so on, and compare the results with those from another group of workers engaged in a different form of work, or with a sample from the general population. Estimation of the relative risk from a cross-sectional study such as this would show whether or not OA was over-represented in the study group. Another approach – using a case-control, or case-referent study – would be to define a group of patients known to have OA – of the hip or knee, for example – match them with patients without OA and determine the occupations of both groups (cases and controls) to see if any occupations were disproportionately represented among the cases; it would then be assumed that the occupations that were over-represented among the cases were aetiologically related to their OA.

Approaching the problem from the other end – the human remains end – is rather different in that the task now is to try to isolate the occupational precipitant (movement) from all the others. In this respect, the situation is somewhat like trying to decide which of five taps is filling a bucket, the water having passed on its way to the bucket through a filter funnel. In this analogy, the taps are the precipitants, the funnel the interactions between them, and the bucket of water represents the outcome (OA in this case). It does not take too much thought to see that in this scheme, there is no possibility of deciding which of the taps has filled the bucket since the outcome is the same irrespective of which tap issued the water. The only way it could be done would be if one tap was producing coloured water; blue water in the bucket must have come from the blue tap, for example, but as already mentioned, there is no variety in the appearance of an arthritic joint no matter what the underlying cause. There is no type of OA unique to any one occupation; so no blue tap. We are thus unable to say whether it was occupation or some other precipitant (or a number interacting) that was responsible for the

development of the joint disease.

There is another way to demonstrate the impossibility of determining occupation from the pattern of OA in the skeleton and that is to suppose that you are in a rheumatology clinic, and you are told that all the patients on that day have OA. You have x-rays of the affected joints in each case, but you are not allowed to see the notes or talk to the patients. Your task is to decide on the occupation of each patient from a consideration of their x-rays. I doubt that many people would place much of their savings on getting the answers right. In fact, it is hard to see how anyone would get *any* right, except by chance. Yet how many bone specialists seem to be confident that they can do what is essentially the same thing? And in what proportion of cases are they likely to be right? The answer must closely approximate to zero on the evidence that they have.

It will not have escaped notice, I hope, that reasoning similar to that above will apply to the attempt to deduce a precise occupation or activity from any feature of the skeleton unless it is known in advance that the particular occupation or activity produces a unique appearance on the skeleton. For example, prominent muscles markings may indicate strenuous use of the muscles that attach there, but that is a long way from ascribing them to hoeing, rowing or towing. In all cases where an activity or occupation is reported to be predicted from the skeleton, the authors should be asked to validate their conclusions, citing clinical evidence from the living, and this they may find very hard to do, and it is a task that is best left undone.

Stress markers and their effects on mortality

There are a number of so-called ‘stress markers’ on the skeleton that are frequently referred to in the literature, usually but not invariably in children. The four stress markers that are generally referred to are linear enamel hypoplasia (LEH), cribra orbitalia, Harris’s lines, and periostitis. Quite what kind of stress is thought to underlie these conditions is usually not made clear; it is certainly not stress in the classic physiological sense of a flight or fight reaction, but the assumption seems to be that it is an untoward event such as a bout of illness, or a chronic disease. Nor is it usually made explicit that the ‘stress’ may vary according to which of the stress markers is under consideration. Be that as it may, it is often considered that the presence of these markers is somehow related to the death of the individual concerned; no-one so far as I am aware, considers that any is *directly* related to the death of the individual, only that its occurrence is a surrogate for some other condition (or conditions) that *might* be so related. Of the four stress markers, only LEH can be seen in the living without recourse to radiography, so let us consider how we might examine the notion that it is somehow related to an increase in mortality, and let us consider children, since it is they who are often considered to have undergone the stress.

Suppose that in a large assemblage which includes many children, there are more children with hypoplasia in each age group over five than those without. Can this be taken as evidence of a relationship between hypoplasia and early death? The suggestion certainly seems plausible, that is, it has a certain amount of face validity, but does it have any other validity? It is instructive to consider how one might go about testing this hypothesis in a modern population of children, since this may help us determine whether it would be practicable in the assemblage.

There are a number of ways in which the relationship might theoretically be studied in a modern population. One method would be to determine the proportion of living children with hypoplasia in each of several age groups – ages 6–12, say – and then in groups of children who have died at each of these ages. These proportions could then be compared with the expectation that if the hypothesis that LEH is associated with increased mortality were correct, then significantly more of the dead children

than the living would be found with hypoplasia within each age group. Or as one student once commented, the kids with hyperplasia die more often than those without – well, you know what she meant.

This particular study would not be easy to carry out given the low death rate in children and it might be more satisfactory to define two other groups, one with hypoplasia and one without, and follow them up for a period to determine their ages at death with the object of seeing whether or not those with hypoplasia were dying at a younger age than those without. Again, not a particularly easy study due to low death rates and the fact that a long follow-up period might be necessary, but theoretically possible.

Of course, neither type of study could be carried out on a skeletal assemblage since both require access to a living population to use as the basis for comparison. Let us now assume that we can calculate the age-specific prevalence of enamel hypoplasia in an assemblage. Having done so, the problem that we now face is that we do not know what the prevalence of enamel hypoplasia was in the living population from which the skeletons were drawn, nor is there the slightest prospect that we ever could know. We are, therefore, unable to calculate the difference in proportions between the dead and the living populations which is what we must be able to do to make any valid inferences about the connection between having LEH and an early death.

The argument in relation to enamel hypoplasia will, of course, apply to any of the other so-called stress markers – cribra orbitalia, Harris lines and periosteal new bone formation – any or all of which have been suggested as being indirectly related to the death of the children bearing them. The general rule to take from this is that if any epidemiological comparison requires information from the living population of which the assemblage was once a part, then the study cannot be carried out.

Height and longevity

There is a considerable literature on the relationship between final achieved height and longevity and the general consensus is that there is a positive association; that is to say taller individuals tend, on average, to live longer than their shorter contemporaries (Davey-Smith *et al.* 2000; Nwasokwa *et al.* 1997). For some iconoclastic views see Samaras and Elrick (1999), Samaras and Storms (2002) and Riley (2000)).

To test this association the modern epidemiologist might decide to construct a cohort of individuals chosen at random, measure their height and follow them up to death. Depending on the age of the members of the cohort this study might outlast the investigator and it is much more likely that he or she would instead identify a cohort of dead individuals and find their height from medical or other records; age at death would be known from the records, or from death certificates. The relationship between age at death and height could easily be obtained and a regression equation calculated, which might indicate how many months of extra life (or how many fewer months – we should not anticipate) could be expected for each centimetre increase in height.

For once, we find ourselves in the same position as the modern epidemiologist, since we also have a cohort of dead individuals, by no means random to be sure, but we can only do the best we can with what we have. Our principal difficulty is in ascribing an age to our subjects, sexing them is more straight forward, assuming the skeletons are reasonably well preserved. Let us suppose, however, that we are satisfied that we have been able to assign reliable ages and sexes to the adult assemblage, we next ascertain height, and plot age at death against height, or mean age at death of individuals of different heights, to see whether or not a relationship exists between the two. When this was done for a large assemblage of individuals recovered from St Peter's Church, Barton-on-Humber, Lincolnshire, no

significant difference was found in mean age at death and height, for either males or females (Waldron 2007, 43–44).

Actually, there is no need to go to the bother of calculating height, it is sufficient simply to use long bone lengths, preferably concentrating on a single bone (the femur, say), or using each bone separately. It should be borne in mind that the more bones used in the analysis, the greater the likelihood of finding a ‘significant’ result, so this might at first seem a good strategy. However, beware those authors who stress the one significant result amongst the twenty tests performed; it is likely to have been due to chance.

In fact, there is theoretically an even simpler way of quickly looking for a relationship. We assume that height (or long bone length) will be normally distributed in the living population and we can further assume that if height has no bearing on age at death, then the heights of the assemblage should also be normally distributed since there will be no tendency for the short (or the tall) to die prematurely and accumulate at one end, or other, of the distribution. If we plot the height or long bone lengths of the assemblage, and if the plots do follow a normal distribution with no tendency for values to accumulate at one end or another, we may infer that there is no relationship between height and longevity in this assemblage, at least.

Implications for palaeopathology of wrong-end epidemiology

Virgil says, ‘Happy is he who has been able to learn the causes of things’, but the reckless pursuit of causes may lead to error, or at least to conclusions that cannot be validated, because of the ‘wrong-end’ position we find ourselves in epidemiologically speaking when examining human remains. Some specific difficulties have been discussed above, but it is possible to generalise the problem by stating that any conclusion, any measure of disease frequency, or any other assumption that requires knowledge of some aspect of the *living* population from which the assemblage was drawn is likely to be invalid. Thus, it is scarcely credible that the occupation of an individual can be inferred from his or her skeleton, or the leisure activities that were undertaken by them, or the degree to which a particular pathological condition impinged upon the life of the individual concerned, unless there is good clinical evidence to support the assumption. For example, the radiological appearances of a joint affected by OA correlate poorly at best with symptomatology, the least poor correlation being found in the case of OA of the knee (Duncan *et al.* 2007). A spectacular case of DISH (diffuse idiopathic skeletal hyperostosis), with extensive fusion of the vertebrae, and florid osteophyte formation would not, in many cases, have greatly incommoded the person in whom it was present, the condition nowadays being most often found as an incidental finding on a chest x-ray. The principal exception to this generalisation would be if the osteophytes in the cervical region were so extensive that they impeded swallowing or breathing as latterly they have been reported to do (Verlann *et al.* 2011). On the other hand, there seems little reason to doubt that a true dental abscess would have been painful, at least until it drained; that rotator cuff disease associated with impingement syndrome would likewise have hurt and also probably impeded movement to some degree; and that a badly shortened and angulated femur would have resulted in some degree of disability or at least a limp. Sound clinical evidence can be adduced in support of all these assumptions, and evidence-based conclusions should be the rule in palaeopathology, rather than wishful thinking.

Given that information about the living would be of the greatest help in palaeopathology and palaeoepidemiology, it is worth giving some consideration as to where such data might be found. One helpful – if not entirely reliable – source is extant parish records, which will give details of christenings, burials, and marriages.³ Parish records may be used to compare expectation of life estimated from the

skeletons, or stillbirth and infant mortality rates. For example, at St Peter's, Barton-on-Humber, long runs of the parish records were extant and it was possible to determine that an average of 26 christenings had taken place from 1570 to 1850. The number of fetuses in the assemblage from the parish for the same period was 57, which, for reasons discussed in the original, was considered to be about a quarter of those actually buried there. On this assumption, the stillbirth rate was approximately 31 per thousand, a rate which seems entirely plausible; the rate in developing countries at the present time is about 20 per thousand. During the same period, there were twelve individuals who had died during the first year of life, giving an infant mortality rate of 6.5 per thousand. Since the infant mortality rate in England and Wales is currently 5.6 per thousand, the rate at St Peter's seems unreasonably low, and may have resulted from some infants having been put into older age groups. (Further details, including the original references can be found in Waldron 2007).

Finally, when trying to infer anything about the cause, or the effects, of changes seen in the skeleton, it is pertinent to ask if a modern epidemiologist or clinician could do so, and how? If to do so requires information than can be obtained only from the living, then the attempt is certainly doomed unless some additional source of information is available. There is probably no harm in seeking the help of an epidemiologist or a clinician when deciding what can or cannot be validly concluded about an assemblage, or an individual case. It may be worth also considering Vico, one of the most original thinkers of the 18th century; in his essay on Vico, Isaiah Berlin (1991, 69) wrote that 'The critical role that he [Vico] assigns to the imagination must not blind us – and did not blind him – to the necessity for verification; he allows that critical methods of examining evidence are indispensable.' As for Vico, so for the palaeopathologist.

Notes

- 1 For further details of modern epidemiology, the methods of study and analysis, the reader should consult any of the many text-books available. For those with only elementary knowledge, either Coggon *et al.* (2003) or Beaglehole *et al.* (2000) would be entirely suitable. The more well informed, or those who like (much) more detail, will find that the third edition of Rothman *et al.* (2008) provides plenty to keep them occupied. Incidentally, the second and third editions of this book are not nearly as good as the first, which Rothman wrote without the aid of co-authors; if you can find a copy of this edition, refer to it for preference.
- 2 Face validity is merely another way of saying that an idea seems reasonable. There are many other types of validity that are used by epidemiologists, including construct validity, internal validity and external validity; a table showing the different types of validity, with their meanings can be found in van Ommeren (2003). It is important to distinguish validity from reliability, with which it is often confused. Reliability refers to the accuracy of a measurement or observation and is usually estimated by re-testing. For example, suppose that we were scoring marginal osteophytes using a three or four point scale, we would test our reliability by re-scoring a random sample of the joints on another occasion; if there was a strong correlation between the scores on the two occasions, we would be justified in concluding that our technique was reliable. Whether it had any validity would be another matter; a method can be reliable but invalid if it does not actually measure what we set out to measure. A longer discussion on this point is given by Malady *et al.* (1992).
- 3 The parish records were established in England following an order of Thomas Cromwell in 1538. Not all parishes complied in the early years and further ecclesiastical mandates followed in 1597 and 1603 which laid down the procedures to be followed. During the English Civil War, the registers were poorly maintained but continued again after the restoration of the monarchy in 1660. With the passing of the Registration Acts of 1836, the parish registers were quickly superseded as a source of reliable national statistics. There are, of course, a number of deficiencies in the records – records were kept only for

those in the communion of the Church of England, and baptisms and not births were recorded, but where they are extant, they are the best source of information on living populations that we have, prior to national registration. (For further details see Tate 1969).

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A typology of dog deposition in archaeological contexts

Angela Perri

Introduction

Dogs (*Canis familiaris*) are the first known domesticated animal and their remains are commonly found from about 15,000 years ago (Larson *et al.* 2012). Dogs have generally been treated as an animal of social distinction, with the liminal position of ‘neither person, nor beast’. Given this social relationship with humans, it is curious that the deposition of dogs has not been afforded more attention in the archaeological literature. Dogs have played a variety of roles in the past, so the interpretation of their remains can be challenging (Olsen 2000; Morey and Wiant 1992). As the dog’s social position varies, so too does its deposition in the archaeological record. While many archaeological sites contain miscellaneous dog remains apparently discarded to avoid the unpleasant attributes of a decomposing carcass, other remains seemingly represent careful, intentional depositions perhaps reflecting a more complicated social relationship between human and animal.

The flexible social position of dogs is important in considering their mortuary treatment. Among the Nuaulu of eastern Indonesia, dogs which are of no practical use or have problematic behavior are killed and disposed of without ceremony (Ellen 1999). Dogs were eaten among many proto-historic Native American groups (Pferd 1987). Textual evidence suggests that the Hittite ‘Ritual of Huwarlu’ called for a puppy to be killed to protect the king and queen from evil (Collins 1990). In some modern aboriginal groups dogs are accorded intentional burials, sometimes with gifts, in return for their role as a valuable hunting partner (Nobayashi 2006). Similarly, throughout the modern world dogs are regularly buried as a treasured companion. Dogs could indeed have simultaneously occupied many roles within a single group, each with differing modes of deposition. With such a wide range of possibilities, how is it possible to interpret a particular dog deposition?

Here I am concerned with identifying the physical characteristics of different modes of dog deposition, in order to create a comparative interpretive methodology. Only through context-specific interpretations of dog deposition will we be able to understand the varying relationships between dogs and humans in the past. The first step is a thorough analysis of the variability of dog deposition. As noted by Morris (2011, 168), separating description from interpretation is often difficult, but by considering them as separate processes, we can build the taphonomic history of a deposit as a foundation for understanding the human actions behind it. This paper aims to construct a typology of archaeological dog deposition, which will enable such an analysis.

Developing a typology of dog deposition

The lack of a common vocabulary for dog mortuary treatment, particularly regarding what is meant by the term ‘dog burial’, has led to widely varying interpretations of archaeological dog remains (Morey 2010; Crockford 2009; Miklósi 2008). Interpretations of ‘special’ depositions of dogs include valuable companion (Jennbert 2003), household member (Fahlander 2008), cenotaph (Larsson 1990a), shaman (Strassburg 2000), symbolic protection (Munt and Meiklejohn 2007), and foundation offering (Olsen 2000). This variety of interpretations is partly due to the diversity of remains labelled ‘dog burial’. Some dogs are deposited alone with elaborate grave goods (e.g. at Mesolithic Skateholm, southern Sweden – Larsson 1990b) or coburied with humans (e.g. at Upper Palaeolithic Bonn-Oberkassel, Germany – Morey 2006; Natufian Hayonim Terrace, Israel – Tchernov and Valla 1997). Others are represented by whole or partial skeletons in rubbish pits or middens or under floors (e.g. at Eneolithic Botai, Kazakhstan – Olsen 2000). The lack of a developed terminology has led to complete, articulated remains with associated grave goods being discussed and interpreted in the same way as fragmentary elements found in refuse. As Morris argues:

Although at first it may appear unimportant, the terminology and language used by archaeologists describing a deposit can greatly influence its interpretation, and importantly, the concepts of other archaeologists. Terms such as ‘special’, to many archaeologists, automatically implies a ritual connotation, similarly ‘burial’, a term utilized mainly for human remains, may conjure images of a ceremonial/ritual event.

(Morris 2012, 8)

The adoption of a common typology for dog depositions should thus enable clearer descriptions and so provide a firmer foundation for in-depth understanding of early human–dog interactions. To this end, the examination of dog depositional data has been carried out on two levels. The first level involves the identification of individual variables manifest in every mode of dog deposition, even if only in the form of absence (Adams and Adams 1991). Four major variables are identified:

- osteological traits
- location
- grave goods
- similarity to human deposition

Within each variable, a set of observed possible characteristics has been defined. An examination of the archaeological dog deposition record shows a marked correlation among sets of these characteristics, leading to the identification of five distinct depositional types:

- isolated
- associated
- component
- elemental

- expedient

These variables and depositional types will be discussed in the following sections.

Major variables

Osteological traits

Articulation and positioning

Until recently, fully and partially articulated animal remains have rarely merited explanation (Pluskowski 2012; Morris 2010), because animal bones were commonly considered of purely economic origin (Hill 1995). This has been particularly problematic for domesticates outside the conventional subsistence sphere, such as the dog, and arguments have been made for a more rigorous examination of these deposits (Morris 2011; Wilson 1992; Olsen 2000; Pluskowski 2012).

Grant (1984) defined 'special animal deposits' as depositions of three types: animal burials, skulls (including mandibles), and articulated legs. However, she also included a number of individual bones in her classification. Not convinced by the word 'special', Hill (1995), in his examination of 'ritual and rubbish' in the Iron Age, adhered to Grant's types, but renamed them associated animal bone groups (ABGs), a term that has become popular for general referencing of articulated animal remains (Morris 2010; Pluskowski 2012). Morris (2011) redefined ABGs as those animal remains which a) have been deposited with attached flesh or connective tissue, causing them to remain articulated, b) are disarticulated through some taphonomic process, but have been identified as a single animal which was likely previously articulated, c) are disarticulated when deposited, but associated and constitute the remains of a single animal. Therefore, he does not include single bone deposits, including isolated skulls and mandibles, in his definition.

For the purposes of this typology, *associated animal bone groups* will include those remains defined by Morris (2011), as well as articulated limbs and individual bone elements, such as skulls, mandibles, and teeth, when found in association with human remains. Fully articulated dog remains have the majority of elements present and in correct anatomical position. Cases where the remains are complete save for a missing element or two should be considered complete if the missing elements appear to be the result of a taphonomic issue or other post-depositional disturbance. Partially articulated remains are those which are in the correct anatomical position, but only have a portion of the articulated elements present. In this category, the missing skeletal elements do not appear to be a result of obvious taphonomic or disturbance issues, but are an intentional partial deposition. This category includes those which have been deposited complete, save for the skull, as well as individual portions such as articulated limbs. Remains with no articulation are comprised of a single element only, most often skull, mandible, or individual teeth.

The way that a dog's body is manipulated and orientated, especially in relation to human and other animal remains, may also be an important indicator of their social position in life (Pearson 1999). The positioning of dog remains is less variable than that of humans. The most common distinction is between intentional positioning, and an absence of positioning altogether. Intentional positioning is the deliberate positioning of the body on one side in an extended or curled position. The head is often placed straight out from the body or curled inwards. A long tail is generally intentionally curled around the backside and placed between the legs, and the feet are often placed with paws gathered together or

tucked under the body. The term ‘haphazard’ has been borrowed from human mortuary terminology, where it is used to describe the arbitrary disposal of the body into a pit, midden, trench or other location (Sprague 2005). Remains with haphazard positioning are those which apparently lack any intentional placement. They are commonly found in twisted, piled or otherwise indiscriminant positions. The heads are often bent backwards with limbs and tails askew. In addition, the cardinal orientation and the side on which the dog has been placed should be noted, as these traits are often repeated and may aid in the interpretation of the deposition (Crockford 2009).

Trauma and pathology

Evidence of physical trauma and pathology, either in life, perimortem, or post-mortem (e.g. butchery), is common in archaeological dog remains and can be important in the interpretation of the relationship between human and dog. These include injury, disease, and/or age-related stress. They include those which appear to be human-inflicted (butchery, skinning marks), pathological (arthritis, dental caries) or indeterminate (broken limbs, healed wounds). Common traumas and pathologies sustained during life include extensive bone pathologies, which may suggest an element of care had been provided. A small dog from a Roman cemetery in Tunisia was found to have severe trauma to the skeleton, including widespread arthritis and advanced tooth loss. Its age was estimated at 15–18 years and it is suggested the animal would have needed great care from humans to have survived with such an extensive suite of disabilities (MacKinnon and Belanger 2006). Perimortem injuries include fatal cut marks (e.g. the cutting of the throat) and severe, unhealed wounds or breakages which point to cause of death. At the Bronze Age site of Százhalombatta-Földvár in Hungary, where dogs were apparently eaten, numerous dog crania were found with severe blows to the frontal bone, a likely mode of dispatch (Vretemark and Sten 2010). Post-mortem traumas include butchery cut marks, skull damage for brain removal or marks from skinning. Many dogs from Iron Age sites in Greece had been skinned before being butchered (Snyder and Klippel 2003).

Age, sex, and size

Age, sex, and size can sometimes be difficult to assess, especially in the case of partial remains or individual elements, but there is evidence that these factors may have played a significant role in the relationship between dogs and humans in various cultures. Dogs of certain ages are known to have been preferred by particular groups for ritual and other symbolic practices. Hittite written sources reveal that the sacrifice of puppies played a vital role in prevention and purification rituals (Collins 1990), while modern ethnography in lowland Nicaragua suggests male dogs may play a greater role in hunting success and thus have a greater value to the society (Koster and Tankersley 2012).

Location

As in human mortuary treatment, the placement of dogs – both the specific location and the spatial distribution – is one of the most visible ways a culture has of expressing the relationship between dog and human. Mobile hunter-gatherers may have practised expedient disposal such as abandonment or shallow deposition due to their highly mobile nature, but special-place disposal or cemeteries were more common among less mobile or sedentary groups (Walthall 1999). In groups that had close social relationships with dogs, the placement of their remains may have been less a function of expediency and more imbued with significance, consistent with the special mortuary treatment of human remains.

In other communities, the locality and distribution of dog remains may mirror the deposition patterns for other domestic animals, such as cattle or swine, suggesting a more secular role for the dog.

The particular depositional settings are quite variable, showing great disparity between geographic locations and cultures. The concentrated deposition of dogs is common in the early Holocene shell middens of Japan (Shigehara and Hongo 2000), the United States (Morey 2006), and northern Europe (Larsson 1989). Dogs are also found in constructed pits, both those meant as graves, and those originally created for another purpose (Cole and Koerper 2002; Morris 2011). In Iron Age England, complete and partial dogs were commonly disposed of in ditches or abandoned storage pits (Hill 1996), and they have been found in a well in ancient Sicily (Chilardi 2006) and kivas in the North American South-west (Hill 2000). The deposition of dogs within building foundation walls or pits is also fairly common, as at Dorchester in Roman Britain (Woodward and Woodward 2004). Dogs are also found in various containers including pots, mugs, and urns (Daróczy-Szabó 2010), coffins (Tooley 1988), and ships (Sikora 2003).

Many dogs were deposited alone, but there is also frequent co-deposition with both humans and with other animals. Likely due to their close domestic relationship, the dog is one of the most common animals found interred with humans. These co-depositions are in various degrees of articulation, from fully articulated skeletons to individual elements like mandibles and skulls. At Ain Mallaha in Natufian Israel, the skeleton of a puppy was found curled next to the remains of a woman (Davis and Valla 1978), while two dogs were associated with six humans in a mass grave at the Archaic site of Braden in the United States (Yohe and Pavesic 2000). At the Mesolithic sites of Lepenski Vir and Vlasac on the Danube Gorge, multiple humans were interred with individual dog mandibles (Radovanović 1999), and a ‘death pit’ from Neolithic Turkey includes highly fragmented human and dog elements, along with those from other animals (Kansa *et al.* 2009). Dogs are also frequently found deposited with other animals, including other dogs. Two dogs from thirteenth–fourteenth century AD California were carefully interred together with associated grave goods (Vellanoweth *et al.* 2008), while a pit full of articulated dogs was excavated from Iron Age Crete (Day 1984). The deposition of dogs with other animals, both domestic and wild, is a widespread phenomenon as seen from Bronze Age (Morris 2011) and Iron Age England (Wilson 1999), Copper Age Hungary (Horváth 2012), and Roman Netherlands (Groot 2012).

Following the definition of ‘cemetery’ in human contexts, a ‘dog cemetery’ would include: a reasonable number of depositions; depositions which are contiguous and patterned; an area with a geographical or cultural boundary; and a site which had not been used as a living area during the period when dogs were being deposited (Pardoe 1988). Clustered depositions of dog remains which closely mirror the deposition of humans are not only seen from modern dog cemeteries in the United States, Asia (Chalfen 2003; Kenney 2004), and Europe (Howell 2002; Kete 1994), but in archaeological contexts as well. The complete dog depositions from the previously described Skateholm site in Sweden were buried individually, and clustered together at the edge of the human cemetery area (Larsson 1990b). Similar cemetery-like groupings are seen at Archaic sites in the United States (Faulkner and Graham 1966; Magennis 1977).

Grave goods

Clarke (1975, 52) defines grave goods as ‘everything within a grave that was intentionally deposited, but that did not form part of the body, the means used to convey the body to the grave or the grave-structure itself.’ Importantly, this definition includes not only those items found *in* a deposition, but also *on* a deposition, such as rocks, monuments, or other markers. Dogs have been discovered with a variety

of grave goods. Grave goods with dogs interred alone may be contrasted to grave goods found with human–dog co-depositions, as in a dog-only deposition the grave goods can be more closely associated with the dog itself. At an Archaic site in Missouri a dog was found deposited alone in a small pit covered with a tumulus of limestone rocks (McMillan 1970), while during the same time period in nearby Alabama another dog was found deposited alone with a heavy layer of shell piled over the interment (Webb 1938). At the Tollifero site in Virginia an individual dog was curled and deposited upon a crude stone pavement, and dogs have also been found beneath stone slabs (Kerber 1997; DeJarnette and Wimberly 1942). In addition to these more conspicuous markers, traces of red ochre have also frequently been found covering individual dog depositions (Larsson 1990a; Cantwell 1980; Brizinski and Savage 1983; Gunn *et al.* 2010).

Dogs are also found deposited with more elaborate grave goods, often on par with those associated with human burials. At Koster a dog was interred with a mano and metate (Morey and Wiant 1992), and a dog at Skateholm was interred with flint flakes, a red deer antler, and an ornate stone hammer (Larsson 1990b). Other dogs interred individually from the United States were deposited with bone awls (Lewis and Lewis 1961), pottery sherds (Miller *et al.* 1962), complete pots (Fitzgerald 2009; Epstein 2010), bones from small mammals (Bentz 1988), and projectile points (Walker and Morey 2005). Two dogs buried together in the Channel Islands of California were found with several items made of materials not native to the island including a sandstone bowl, seeds of morning glory (*Convolvulaceae*) and wild cucumber (*Marah macrocarpus*), and a splintered fragment of redwood (*Sequoia sempervirens*) (Vellanoweth *et al.* 2008).

Similarity to human deposition

It is often argued that the nature of ‘personhood’ in life is reflected in mortuary treatment (Gillespie 2001; Pearson 1999), and that this theory can be applied to the mortuary treatment of dogs as well, given their close relationship with humans (Morey 2006; Hill 2000). When possible, the characteristics of dog deposition should be compared to that of human remains at the same site (Flores 1999).

Similarities between human and dog deposition have been noted throughout the archaeological record. In Australia, dog remains have been found wrapped in paperbark and placed within rockshelter clefts, mirroring the mortuary treatment of humans and suggesting preferential treatment over other animals (Gunn *et al.* 2010; Mulvaney 1996). The individually deposited dogs from the Tollifero site in Virginia ‘were as carefully interred as those of the humans’ (Miller 1962, 243). In the Archaic mid-south of the United States, ‘many dogs were buried with the same degree of attention to grave pits and placement of body as was accorded to their human contemporaries’ (Webb and Haag 1939, 155), and ‘dogs were often buried with the same care as that given to human burials’ (Webb 1950b, 272; see also Webb and Haag 1940; 1947; Webb and DeJarnette 1942; 1948;). In Wisconsin in the Woodland period, not only are the physical characteristics of dog and human mortuary treatment comparable, but isotopic analysis shows they shared a similar diet (Epstein 2010). At one site, where a dog had been bundled and interred identically to a human, it is proposed that the treatment of the dog had gone beyond what was expected for a sacrifice and must be the result of an attributed status within the group (Van Langen and Kehoe 1971).

While parallels between human and dog mortuary treatment is commonly considered evidence of a dog’s elevated status, some researchers instead suggest that individually interred dogs, especially those with grave goods, are cenotaphs or symbolic substitutes for a missing human occupant. At Skateholm, where a handful of dogs have been individually deposited, including one with the richest grave goods of any dog or human, it has been suggested that dogs likely represent surrogates for their

human masters (Larsson 1989). At sites in the Archaic mid-south of the United States it has been suggested that the propensity for male dog depositions, coupled with evidence for raiding and violence, may mean dogs acted as stand-ins for human victims that were irretrievable. However, this hypothesis is questionable, because some sites have dozens of individual dog depositions. This would equate to massive losses to the community (Claassen 2008).

Depositional types

The interpretation of dog depositions has always been problematic (e.g. Wilson 1992; Hill 1995; Savioz 2012). Efforts have been made to distinguish between the different modes of dog deposition, but these rarely venture beyond ritual vs. economic. Terms such as ‘special’, ‘sacrifice’, and ‘burial’ are often used for deposition which are articulated and associated with some sort of grave goods, while everything else is usually assumed to serve some more mundane function (Grant 1984). It is rare for any of the descriptive terms to be defined. Hill (1995) has highlighted the need to examine the agency involved in different types of articulated animal remains. Pluskowski (2012) has stressed the need for documentation and publication of ABGs, noting that such deposits need to be viewed as human constructs. The dog’s variable social role and liminal position between human and animal makes interpretation particularly challenging, especially without an established classification of deposition types observed across the archaeological record. The depositional types presented here are the result of an extensive examination of the archaeological literature, but cannot be exhaustive. The types are characterized by the recurrence of similar sets of the characteristics described above. It is proposed that through the identification of these patterns interpretation of the remains will be advanced on both an individual site and a cross-cultural basis. Table 11.1 summarises the following discussion.

Isolated

An isolated deposition displays full articulation, except when there have been taphonomic or post-depositional disturbances. The deposition is always deliberately positioned, often with the paws gathered together and tail curled under the body. There is no perimortem or postmortem trauma, indicating the dog was not butchered, skinned, sacrificed, or killed by a human. Traumas and pathologies sustained during life, such as healed broken limbs, may be present. Age, sex, and size are all variable, though isolated depositions appear more common among adult dogs. Isolated depositions may be found in various locations, or they may be clustered in ‘dog cemeteries’.

A key identifying feature of isolated deposition is the absence of any co-deposition. They are commonly found in deposition pits, layered shell middens, or other features that closely mirror the burials of humans at the same site. Like many human depositions, isolated depositions often incorporate grave goods, including red ochre and grave markers. An isolated deposition is what I propose should be termed a true ‘dog burial’. This depositional type involves the level of care and attention generally afforded to human burials and, most importantly, the significance assigned to the deposition is beyond what is typically provided to a non-human animal.

Table 11.1. A typology of dog deposition in archaeological contexts.

<i>Characteristics Types</i>	<i>Articulation and positioning</i>	<i>Trauma and pathologies</i>	<i>Age/sex/size</i>	<i>Location</i>	<i>Grave goods</i>	<i>Similarity to human deposition</i>
<i>1. Isolated</i>	Full articulation (possibly partial if disturbed); placed positioning	No perimortem or postmortem trauma, possible trauma during life	Variable	No co-deposition, burial pit common, possible 'dog cemetery'	Possible	Usually closely mirror human burials at same site
<i>2. Associated</i>	Full or partial articulation; placed positioning	Possible trauma from life, perimortem, & postmortem	Variable	Always co-deposition with human burial	None associated with dog	Not applicable
<i>3. Component</i>	Full articulation (possibly partial if disturbed); placed positioning	Possible trauma from life, perimortem, & postmortem	Variable	Possible co-deposition with humans/other animals; deposition pit common	Possible	Possibly similar in 'ritual' contexts
<i>4. Elemental</i>	No articulation; no positioning	Possible trauma from life, perimortem, & postmortem	Variable	Always co-deposition with human burial	None associated with dog	Possibly similar though uncommon
<i>5. Expedient</i>	Full, partial, or no articulation; haphazard positioning	Possible trauma from life, perimortem, and postmortem	Variable	Possible deposition pit, but convenient disposal location more common	No	Possibly similar though uncommon

One of the best examples of isolated deposition comes from Skateholm. Here several dogs display isolated deposition, with individual deposition pits and a lack of perimortem or postmortem trauma; one was buried with abundant grave goods (Larsson 1990b). Similar carefully placed isolated dog burials are seen in the Archaic shell middens of the mid-south United States at the Perry site (42 isolated depositions; Webb and DeJarnette 1942), the Carlson Annis site (25 isolated depositions; Webb 1950a), the Read site (23 isolated depositions; Webb 1950b), and the Indian Knoll site (11 isolated depositions; Webb 1946), among others. Isolated depositions occur in many places including Europe (Brinch Petersen and Meiklejohn 2003; Louwe Kooijmans 2003; Larsson 1990b), the United States (Kerber 1997; Breitburg 1983; Dowd and Breitburg 1989), Asia (Shigehara and Hongo 2000; Hasebe 1952), and Australia (Gunn *et al.* 2010).

Associated

Associated depositions are defined as the inclusion of a dog or dogs in the burial of humans. The dog(s) are in full or partial articulation and are often deliberately placed, though haphazard positioning is also possible. They may show evidence of butchery, decapitation, skinning and other trauma, both pre- and post-mortem. Age, sex and size are variable, and other animals may also be included in the burial.

Two examples of associated deposition come from the Natufian period in the southern Levant. At Hayonim Terrace two fully articulated dogs were deposited with the bodies of three humans in an egg-shaped pit along with tortoise shells, and covered with a limestone block upon which the humans were then placed (Tchernov and Valla 1997). At Ain Mallaha a puppy was deposited with a human (Davis and Valla 1978). Variations occur around the world (Hamilakis 1996; Tuck 1976; Yohe and Pavesic 2000; Geus 1991; Olsen 1985; Blau and Beech 1999; MacKinnon and Belanger 2006).

Component

Dogs in a component deposition are usually fully articulated, save for taphonomic or post-depositional

factors, but are sometimes in partial articulation. They are interred either alone or with other non-human animals, in a prepared pit or other intentional depositional setting, and are deliberately positioned. In a very important contrast to an isolated burial, this type of deposition is located outside any collective dog cemetery. The dogs often display peri- and/or postmortem trauma consistent with dispatch, butchery and/or skinning. Age, sex, and size are variable, although component depositions often show consistency in the age of dog (Collins 1990). The dogs are sometimes found with grave goods, often referred to as altar offerings or ritual goods (Olsen 2000).

The term ‘ritual’ is not applied to component deposition because of the problematic nature of the term. These are depositions which imply some alternative function beyond the mere deposition of a carcass. This could be anything from religious or cult-related to secular and more practical purposes. A key to interpreting component deposition may lie in the historical literature, which suggests domestic animals, specifically dogs, are among the preferred animals used for ‘ritual’ killings (Pluskowski 2012). Such depositions may follow specific sequences, with applied rules, throughout a cultural group, which makes them easier to identify in the archaeological record (Richards and Thomas 1984). The common practice of depositing dogs in building walls or foundations, perhaps as a symbol of healing and protection (Morris 2012), has led some researchers to refer to these component depositions as dedicatory interments (Emslie 1981).

The deposition of dogs beneath structure floors (Ó Súilleabháin 1945; Loehr 1957; Day 1984; DeJarnette and Wimberly 1942) may correspond to ethnographic descriptions of the deposition of sacrificed dogs (Erb 1991; Mery 1968). At the Eneolithic site of Botai in Kazakhstan, at least 15 dogs were deposited in component interments. Both complete and partial, they were placed in pits to the west of houses, a location associated in Indo-European and Indo-Aryan mythology with an ‘Otherworld’ guarded by two dogs (O’Flaherty 1981; Jones-Bley 1997). Across the rest of the site numerous dogs were interred in pits beneath house floors, many associated with ochre, flint, projectile points, and various other faunal remains (Olsen 2000).

Elemental

Elemental deposition is the inclusion of individual dog skeletal elements, most often skull, mandible, or teeth, in the burial of humans. They are always associated with human remains. As they involve only single elements, there is no articulation or specific positioning, and the age, sex, and size of the dogs are variable. These elements often show evidence of trauma, specifically related to skinning, butchery, or dispatch. The inclusion of dog elements with human burials is often interpreted as grave goods (Parmalee 1960; Kerber 1997; Gräslund 2002).

Several examples of elemental deposition have been found at Mesolithic sites along the Danube Gorge. At Lepenski Vir, a single dog mandible was found with elements from various other animals in the burial of a human male, and at Vlasac two human males were found buried with dog mandibles (Radovanović 1999). The deposition of dog skulls, mandibles, and teeth with humans is a fairly common phenomenon worldwide, for example in the Late Eskimo period in Canada (Osborne 1952), Romano-British Oxfordshire (Wilson 1986), seventeenth century Barbados (Handler 1997), Iron Age Italy (Facciolo and Tagliacozzo 2006), prehistoric Louisiana (Webb 1948), Neolithic Latvia (Zagorska 2008), and Late Shang China (Ying 2009).

Expedient

Expedient deposition is a miscellaneous type that is defined more by negative evidence than the

characteristics which it displays. It is sometimes referred to as a simple interment (Hill 2000), nonburial, or refuse (Beisaw 2007), due to the apparent lack of attention and expedient nature. The animal may be fully or partially articulated or completely disarticulated, and body positioning is haphazard. There may be evidence for a deposition pit, but more commonly these remains are deposited in trash middens, trenches, wells and other locations which facilitate convenient disposal. Trauma is common, specifically butchery or skinning marks and there are no grave goods. Age, sex and size are all variable.

This category includes all those depositions which cannot be included in the categories defined above, and is therefore very common. It has been suggested that dogs in this category were culled due to illness or as community pests (Morey 1997), butchery debris (Chenal-Vélardé 2006), and ritual trash (Russell *et al.* 2009). Hill (2000) suggests that as dog interments become a more prominent focus of contextual analysis, the expedient type will be defined in greater detail, or eliminated as more comprehensive patterns of dog interment are identified.

Limitations of the typology

Typology is not without its limitations. Most importantly, it must be stressed that interpretations cannot be tied directly to the typological categories. These types are merely starting points from which the context and individual variables from each deposition must be introduced. As observed through our everyday encounters, a dog can be many things at the same time, and mode of deposition does not necessarily reflect position in life. Moreover, as more dog depositions are excavated and analysed, additional categories will no doubt be defined. Perhaps the most challenging obstacle to this typology (and any associated interpretations) is its reliance on the physical characteristics of the deposition as found and reported by the original excavation team. There have been calls for the detailed recording of dog depositions (Crockford 2009), but descriptions of faunal remains, specifically those made before the proliferation of zooarchaeology, are often severely lacking in the detail needed to confidently identify the type of dog deposition encountered.

More specific issues arise from the physical nature of the depositions themselves. Post-depositional disturbances and taphonomic effects can severely alter the physical characteristics of the deposition, proving problematic when categorizing a deposition type. Additionally, mortuary processes such as bundle depositions and cremation, often seen in dog depositions (Williams *et al.* 2001; Kerber 1997; Mäntylä-Asplund and Storå 2010), can be challenging as they often leave little in the way of physical evidence of articulation, positioning, trauma and pathologies, age, sex, and size. It is hoped that the use of this typology will bring about more detailed analysis and discussion between researchers about depositions, confronting and eventually resolving the issues that currently affect this typology.

Conclusion

The dog's history of varying cultural roles and a liminal social position between animal and human has led to highly variable depositional modes, as well as interpretations of these modes. The creation of a shared vocabulary for dog depositions is essential to interpret their meaning and eventually reach a better understanding of the human–dog relationship in the past. A critical part of creating this vocabulary is the separation of the description (how) from the interpretation (why) of the interment. The development of a descriptive language for dog deposition through the typology proposed here will

lead to clearer interpretation on both a site and cross-cultural level. The methodical analysis and reporting of each deposit will allow researchers to discuss depositions using a common terminology, thus encouraging comparison between sites. Hopefully the use of a descriptive typology will encourage a more thorough examination of dog mortuary deposits, leading to additional characteristics and types being identified, as well as an improved understanding of depositions from different archaeological sites.

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The boundaries of the world. The archaeology of humans and animals in southern South America

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Introduction

This paper is about human–animal interactions in the margins of the South American landmass, and it is inspired in Tony Legge’s style in writing and thinking, as well as in our own interactions with him. What was most inspiring about his style was his ability to reach the grand themes and questions in archaeology through a succession of little anecdotes or details in diverse stories. In other words, he could frame a rich and appealing account while taking the audience, without their realising, to think over the most profound matters.

As to our own interactions with Tony Legge, he was one of the first bone people we came across when we took archaeozoology lectures in the UK as part of our doctoral studies. He took the time to introduce us to other researchers, share curious bone stories, and spent some time with us at a local pub. He made us feel at home indeed, as others have noticed as well (see, for instance, Serjeantson and Rowley-Conwy 2013). We remained in touch ever since, and he was always prompt to answer our enquiries.

Here we are picking up on our last significant academic interaction, when he commented on the papers presented at the ICAZ 2002 International Conference session on zooarchaeology in marginal areas (Mondini *et al.* 2004). This issue interested Tony at the time, when he made a wonderful contribution, appropriately starting with a childhood anecdote of his first impressions of the human adventure of living in the margins (Legge 2004), and we think the subject would still appeal to him today.

In this paper, we take up the issue of marginality again, starting from the meaning of this concept in archaeology and related disciplines. After this overview of the way the margins of the world have been conceived of, we deal with the questions we are currently interested in, with a focus in human–animal interactions in our study region: southern South America. These questions have to do, among other issues, with the biogeography of the region and the pathways followed by human populations while incorporating into an ecological community that was “marginalized” after ages of isolation (Simpson 1980, Cione *et al.* 2007, Solari *et al.* 2013), and into a continent which was the last one to be colonised by hunter-gatherers (Gamble 2013).

Marginality in archaeology and beyond

The concept of marginality is deeply rooted in archaeology. In reviewing the different conceptions of marginality in the field, Coles and Mills (1998) suggest there are multiple, overlapping definitions and, not surprisingly, none of them is itself completely satisfactory. They have recognised at least three definitions: an environmental one, an economic one, and a socio-political one (see also Porter and Marlow 2007; Whyte 2013, among others). A biogeographical conception of marginality has also been identified, which refers to the boundaries of the geographic range of humans and other hominins (Mondini and Muñoz 2004). We then proposed that in order to understand the whole range of hominin adaptations and behaviours, such as the reasons and mechanisms of range expansion and variations in resource niches, the so-called marginal areas have a role to play. The rationale underlying this conception of marginality is that factors such as environmental conditions and selective pressures are not evenly distributed throughout the range of a species, and the position of any given population within this range is itself a source of variation (see Pianka 1994; Hengeveld 1990; Ferro and Morrone 2014, among others). Geographic range margins tend to be unfavourable in one or more niche dimensions – which help shape range boundaries – (e.g. Pianka 1994; Brown *et al.* 1996). This in turn leads us back to the importance of understanding behavioural variability under marginal environmental conditions, as this is interesting not just in itself, but also as a source of information regarding our own shifting biogeographic history.

Marginality is thus usually regarded as a property linked to the location of entities such as organisms, populations, and adaptations near the boundaries of a distribution, as well as in relation to limiting factors affecting those entities, be they environmental (i.e. one or more key environmental variables being reduced or even lacking), economical, social and/or political (Whyte 2013), and, we may also add, biogeographical and demographical (see Mondini and Muñoz 2004; Borrero 2004a).

Also, marginality can be linked to perceptions, as lands that are considered to be marginal in modern days may not have been so to other, past actors (Whyte 2013). Not only the properties of these environments may have undergone significant changes, but also – and even in cases they have not – the variables considered to be relevant and their value are diversely perceived by different populations and individuals. For instance, the notions of isolation and marginality have been associated with the extremes of the world for a long time. Such a viewpoint has been a significant stimulus to early research on human societies that were considered to have already gone extinct in most of the world and, due to isolation, were perceived as evidence of a surviving past in the outskirts (Gamble 1992).

As we put it, marginality is not an inherent property of areas or environments but a relative quality (Mondini and Muñoz 2004). It is relative not only as regards the areas and environments, but also the species, populations, and individuals involved, and this is particularly so when the species considered is as phenotypically flexible as modern humans. It is relative to the actors' perceptions as well, and also as regards the academics and anybody else interested in the subject (also see Coles and Mills 1998; Cullen and Pretes 2000). In turn, all of these aspects are subject to changes in time, so that marginality is relative to history as well. The academic community itself may change perspectives and shift the way marginality is conceived. For instance, while marginal, peripheral biotic populations were long considered of low conservation value, more recently it has been suggested that under certain conditions they persist more often than do central populations, and that they are not genetically impoverished, thus playing an important role in conserving declining species (Channell 2004). Also, as Whyte (2013, 302) puts it, 'while marginality can lead to vulnerability it can promote adaptability.' Given this relativity in the conception of marginality and the overlapping definitions developed through time and across disciplines – not to speak of the common-sense, often negative flavour of the

word ‘marginal’ – whatever definition is adopted, it is necessary that it be explicit.

South America as a marginal region

The nature of the South American continent has been described as marginal, overwhelming, mysterious, and desperate as early as at the time of the Spanish explorers. This view has led, among other things, to a fantastic zoology, driven to a large extent by fear (Brailavsky 2007). The exotic character attributed to these lands was not restricted to such early times, though. South America has certainly been part of the viewpoint that marginality and isolation resulted in a surviving past, especially in the 1800s. This is apparent in the belief that the south of the continent was populated by giants (Duviols 1997), cannibals (Darwin 1997 [1845]), or living Pleistocene fauna well into the nineteenth century (Prichard 1902, in Borrero 2001a).

Such a perspective was not exclusive of the Metropolis, but was also shared by the young national states, which were incorporating these territories into their boundaries at the time. In this context, they organised several scientific expeditions aimed at generating information on these regions, unknown to the rest of the world (Navarro Floria 1999). In general, this research emphasised not just the remoteness of these southern lands, but also the severity of their climate and their changing conditions. This contributed to creating an image of southern South America – especially, but not exclusively, the Patagonian region – as dominated both by its isolation and its harshness and inhospitality (e.g. Moreno 1899; Bird 1938).

The idea of marginality and remoteness also underlay the interpretations given over the last century to the human societies inhabiting these South American areas. For instance, the idea of the cornering of human populations in Patagonia (Furlong 1917; Menghin 1952) was linked to the alleged influence of the harsh environment upon these populations (Butler 1957; Steager 1965), as well as to an apparent lack of cultural change, such as in the notion of area (see Steward and Faron 1959). This was not necessarily linked to the specifics of Patagonian cultural history, but was also considered to be a result of environmental conditions and remoteness that could also be found in other regions of the world (e.g. Sutton 1982).

In fact, this point of view driven by environmental harshness and isolation is not exclusive of the latitudinal extremes. The high-altitude, arid Andean Altiplano has been conceived as environmentally extreme and as hosting ‘impoverished’ cultures as well, as compared to the civilizations in the Central Andes (e.g. Troll 1935; 1958; for a review of these viewpoints, see Muscio and López 2011). On the other hand, not only harsh environments have been conceived of as marginal. The very idea of tropical diversity has been linked to a form of ‘scientific ethnocentrism’ that regards tropical environments as out of the rules, being such rules defined out of mild, temperate settings in the northern hemisphere, the home of most researchers interested in these areas (Haille 1999).

South America was the last large landmass to be colonized by human foragers, and as such it was a marginal land to the known world for Pleistocene peoples (Gamble 2013, among others). These foragers had to deal with empty landscapes, devoid of other humans, and also with unknown physical environments and ecological communities, which were highly diverse (Dillehay 2000; Gamble 2013). These communities had in turn been ‘marginal’ for ages, as the subcontinent had been isolated from its northern counterpart until about 3 million years before, when the Panama isthmus formed (Simpson 1980; Adovasio and Page 2003; Solari *et al.* 2013; Thompson 2014). As they expanded their range into the Western hemisphere, humans had to face these ‘marginal’ and otherwise challenging environments such as tropical rainforests (Politis and Gamble 1996; Gnecco 2000; Aceituno *et al.* 2013). Understanding the behaviours involved in such range expansion and adaptations, while considering the

physical and biotic properties of the region, is key to comprehending how our species became cosmopolitan (Muñoz and Mondini 2008; Dillehay 2009; Gamble 2013).

Human–animal interactions in the southern boundaries of the world

In order to understand human–animal interactions in the margins of the New World, the initial characteristics of human foraging adaptations before entering the Western Hemisphere, as well as the physical and biotic properties of southern South America are to be considered, as they represent the conditions under which such interactions took place here.

Like hominins in Eurasia, humans entered the predator guilds of the Western Hemisphere quite late, and like their ancestors, they became definitely successful here at a time of considerable changes in mammal communities and environmental conditions (see Stiner 2002; Ortiz-Jaureguizar and Cladera 2006; Cione *et al.* 2007; Aceituno *et al.* 2013; Borrero *et al.* 2013; Brook *et al.* 2013; Prevosti and Martin 2013, among others). Although the issue of when human populations first entered the Americas is still much debated (see for instance Bueno *et al.* 2013 for South America), it is clear that in the final Pleistocene they were still in the process of colonising most South American regions (Borrero 2004a; Borrero 2004b, Gnecco and Aceituno 2004; Borrero *et al.* 2013). And this process included varied ways of interacting with and impacting these environments from the very beginning (Stahl 1996; Gnecco 2000; Barnosvsky and Lindsley 2010; Aceituno *et al.* 2013; Cooke *et al.* 2013; Borrero 2014, etc.).

Geographically, southern South America forms a peninsula within an oceanic hemisphere, and biogeographically, it belongs to the Andean-Patagonian subregion of the Neotropics (Morello 1984; Morrone 2014, and references therein; for a review of these factors upon human–animal interactions, see Muñoz and Mondini 2007; 2008). The post-glacial scenario in temperate South America after the Pleistocene extinctions is one with many ecological niches only partially occupied by mammals as compared to North America. Even when mammal body sizes are similar, there are generally fewer species per feeding niche here (Keast 1972; Redford and Eisenberg 1992). This low saturation of mammalian faunas, especially the large ones, is in fact in agreement with the more general trend in post-glacial times, consisting of more smaller-sized species but with more individuals than before (Snook 2008). On the other hand, the landmass of southern South America has a peninsular shape, with little available land to the south (Morello 1984). While in the northern portion of South America, about half of mammalian species are bats, to the south, it is rodents that prevail. The Southern Cone is dominated by rodents and carnivores and, in the southern end, by marine mammals (Redford and Eisenberg 1992).

These conditions offered opportunities for a relatively wide diet breadth relative to available species richness for colonising human populations in South America, as compared to other, more saturated contexts such as Pleistocene Eurasia (Muñoz and Mondini 2007; 2008). In the latter continent, humans have been the only predator to preferentially target the reproductive core (prime adults) of ungulate populations since at least 250 kya (Stiner 1990; 1994; 2002). In South America, instead, a more heterogeneous picture emerges, related to more opportunistic foraging strategies strongly linked to regional diversity. This is evident since some of the earliest records of human dispersal in the subcontinent, both regarding plants and animals (see, for instance, Dillehay 2000; 2009; Lavallée 2000; Borrero 2011; Aceituno *et al.* 2013; Gamble 2013).

In southern South America, even when megafauna was available, it was usually not the preferred prey, and even when it was exploited, it was so in an opportunistic fashion (Borrero 2009; Dillehay 2009). This includes scavenging and the hunting of just a few individuals of a small number of

the available species (e.g., Politis *et al.* 2004; Martin 2013). In fact, viewed from the Americas as a whole, the specialised hunting of megafauna inferred in part of North America in Clovis times (see discussion in Grayson and Meltzer 2003; 2004; Fiedel and Haynes 2004) cannot be generalised to the whole Western Hemisphere. Taking into account that prime-aged ungulates had long been the staple prey in Eurasia, even when megafauna was extant (Stiner 2002), and also possibly the differential availability of megafauna in North and South America, this is no surprise (see Borrero 2009; 2006 for a discussion on related topics).

Among ungulates, prey targeting in southern South America has not been as selective as in the Old World either. Here, a range of individuals were often preyed upon in an opportunistic fashion, including young and senile ones besides prime-aged adults (e.g. Yacobaccio and Morales 2011). This resulted in part from ungulate behaviour and predictability as well as human demography (see Muñoz and Mondini 2008; Borrero 2014).

Besides, small animals were captured in a systematic way in some areas of South America since early times. This included all kinds of marine, flying, fluvial, and terrestrial small faunal resources, including slow, 'gatherable' as well as agile, warm-blooded ones, and possibly others like locusts (e.g. Dillehay 2000; de France 2001; Borrero 2014). It is a relevant characteristic of some of these common small prey that they live in colonies, as in the case of chinchillids. These animals rebound quickly, and search and capture costs are relatively low as compared to small animals living in pairs or just solitarily, like higher-ranked, commonly exploited Eurasian species (see Stiner 1990; 2002; Kuhn and Stiner 2001). Some small animals, the rodent cuy or guinea pig (*Cavia porcellus*) and the pato criollo or muscovy duck (*Cairina moschata domestica*), were even domesticated in South America (Stahl 2008). While in the Old World the 'evenness' in the exploitation of the high- and low-ranked small taxa resulted from human hunting pressure over the former under conditions of increasing demographic densities (see Stiner 1990; 2002), in South America, instead, it is an expected outcome of an opportunistic foraging strategy (see Borrero 2006; 2014).

Generally, then, a more opportunistic picture of human–animal interactions emerges in South America as compared to that in the Old World, where many human–animal interactions evolved (see Muñoz and Mondini 2007; 2008, for a review of the conditions leading to such an opportunistic foraging). In this continent, high-ranked animal prey taxa and individuals were not as selectively preferred. Besides, this refers not only to animals, but also to the trophic level generally, as early foragers are known to have exploited a range of plant resources and landscapes in the New World ever since the final Pleistocene (e.g. Aceituno *et al.* 2013; Borrero 2014). Incidentally, this may have helped maintain viable demographic densities as compared to populations with more strictly carnivorous diets.

In spite of such early dietary niche breadth and opportunistic subsistence in South America, camelids have long been humans' staple prey in much of the continent (e.g. Mengoni Goñalons 2008). This relates to the fact that they are the ecologically dominant ungulates. Also, they are territorial – their territories being based upon feeding grounds, although this is not exclusive, since they also form big unpredictable groups (Franklin 1982; 1983, among others) – and this would have promoted hunting efficiency by humans (Muñoz and Mondini 2007; 2008; see Binford 2001). Humans and camelids thus developed a coevolutionary relationship that not only involved the wild guanaco (*Lama guanicoe*) and vicuña (*Vicugna vicugna*) (e.g. L'Hereux 2008), but also eventually led to their domestication into llamas (*Lama glama*) and alpacas (*Vicugna pacos*), fostering the productivity of this long preferred prey (e.g. Mengoni Goñalons 2008; Stahl 2008).

Both in the case of large and small autochthonous animals, domestication would have occurred in a context where human demographics were stabilising and increasing in the region, probably approaching the carrying capacities in some areas – which would have lowered, at least in part of the

region, during the Hypsithermal – (Stahl 2008; Mondini 2013, among others). Thus, intra- rather than inter-specific selective pressures were becoming increasingly important (see Muñoz and Mondini 2008). While here it occurred within a quite different set of inter-specific predatory relationships (Mondini 2004; Stahl 2012), this can be traced back to animal domestication in the Old World as well (Stiner 2002). As Stiner puts it, ever since the Upper Paleolithic, selective pressures came from the lay of cultural landscapes as much as from natural ones. Although for different reasons, and from different backgrounds, this was probably true in South America as well by the time of the domestication of autochthonous animal species in the Middle Holocene.

Humans have co-evolved not only with prey, but also with other predators in South America. Humans coexisted with Pleistocene carnivores, as is evidenced in areas like the southern tip of the continent (Martin 2013), and they do with extant ones (e.g. Mondini 2004). The adaptive zone of hunter-gatherers would have overlapped to some extent with that of the larger Neotropical mammalian carnivores, although after the megafaunal extinctions, most of them are smaller (Berta 1988; Redford and Eisenberg 1992; Muñoz and Mondini 2007; 2008; Martin 2013). The post-glacial predatory fauna is largely unsaturated here, and local carnivores – quite unlike humans – are mostly solitary, so that interspecific competition would not have prevailed in human–carnivore interactions. Although higher levels of competition have been postulated for the Southern Cone in Pleistocene times (Borrero *et al.* 1998 in Martin 2013; Prevosti and Martin 2013), the human feeding niche would mainly have overlapped only with that of large felids, which on the other hand would also have provided opportunities for a scavenging niche, being also large opportunistic predators with a scavenging component (Borrero *et al.* 2005; Martin 2013).

Available taphonomic information in South America is consistent with this and suggests quite a different scenario as compared to that in Eurasia. Here, evidence of resource overlap between humans and other large predators is not as ubiquitous, neither as regards their focus in ungulates or in rocky shelter (Mondini 2004; Martin 2013), being a common interest in these high quality resources one of the most likely forums for periodic competition in large predators (see Stiner 2002). Rather than thin hominid components alternated with thick carnivores occupations, the opposite is more common here, which we have called the ‘dilution effect’ (Mondini 2005). These facts suggest that interspecific competition with mammalian predators has been low or at least intermittent in our continent, especially after the extinction of Pleistocene megacarnivores, (Mondini 2004; Muñoz and Mondini 2007).

Human hunter-gatherers are social predators that did not need to customarily compete with carnivore packs in South America, as in other contexts where hominins evolved. Generally, intra-specific competition of humans and other predators would not have been as keen, especially after megafaunal extinctions, with the decline of mammalian carnivores with overlapping interests, namely the larger felids here (Saxon 1979; Mondini 2004; Prevosti and Martin 2013, de Oliveira and Pereira 2014). Furthermore, camelid domestication would have depressed the productivity of these competing predators (see Stiner 2002). On the other hand, it would have attracted the most conspicuous carnivores in Andean South America: the commensal native canids (Berta 1988; Mondini 2004; Stahl 2012).

Thus, one remarkable aspect which is relevant to understanding human–animal interactions in South America is precisely that biologically-based patterns should not always be attributed to competition, a concept often over-emphasised as a factor structuring communities (*e.g.*, Strong *et al.* 1984). Generalised symbiotic interactions such as commensalism can be as much or even more structuring under some conditions, such as those found in southern South America (Mondini 2004; Muñoz and Mondini 2008; Stahl 2012).

Some final thoughts

The phenotypic plasticity of our species and the technological repertoire – in the widest possible sense – that was available were necessary conditions to the successful colonisation of the Western Hemisphere and to the long-enduring human–animal interactions developed here.

In the Old World, all hominins were essentially K-selected organisms, and thus competitive efficiency rather than reproductive efficiency was selected for (Stiner 2002). The rapid spread of Upper Paleolithic populations at the expense of Neanderthals, as well as the agricultural revolution, may represent exceptions to this generalization. Human dispersal into the New World, and into South America in particular, would represent another exception (Muñoz and Mondini 2008). Here, biotic and abiotic conditions such as those reviewed above would have relaxed the conditions for inter-specific competition, and in conjunction with the social and technological background of these early populations, would have favoured a relatively wide diet breadth, and ultimately efficient reproduction even under low demographic densities in the long run (for a review of these conditions and their consequences, see Borrero 2006; Muñoz and Mondini 2007; 2008).

It is noteworthy that one condition that would have favoured such efficient reproduction that eventually allowed the successful human dispersal into the New World would have been the maintenance of open social networks (Gamble 2013, for a discussion on related topics see Borrero 2014), although local population fragmentation and extinction would have occurred whenever such networking failed (Borrero 2001b; 2014; Rothhammer and Dillehay 2009). These networks would have granted not only the necessary gene flow, but also, as regards human–animal interactions, the necessary managing of resource risk (see Stiner 2002; Meltzer 2004). Monte Verde, with its complex biotic record (Dillehay 1997), may be considered as an instance of such managing. Such networking and conduits for managing resource risk would have evolved in the Old World under much more saturated demographic conditions, although once emerged, they may persist under lower demographic densities (Stiner 2002), as would have been the case in the New World.

Once human populations progressively became established in the continent, other aspects of human–animal interactions became relevant in southern South America. This partly relates to the fact that, as the food niche widened and population increased, selective pressures would have started favouring K strategies in some areas (for a discussion of this, see Muñoz and Mondini 2007; 2008). This would have affected human relationships both with prey and with other predators. As outlined above, prey exploitation intensified, eventually leading to the domestication of some of them (Mengoni Goñalons 2008; Stahl 2008). Concerning predators, symbiotic interactions, particularly commensalism, became a regular arena of interaction (Mondini 2004; Stahl 2012).

Another aspect that merits attention from a zooarchaeological perspective is human impacts on environments and faunas from the very beginning of the occupation of these lands, and probably more intensely after the onset of Holocene conditions and that of K selective pressures. Some of these impacts would even be markers of the beginning of the Paleoanthropocene or even the Anthropocene (Foley *et al.* 2013; Smith and Zeder 2013). Even though not all of them might sound as spectacular as the human impact on tropical forests (e.g. Gnecco and Aceituno 2004), the alleged human impact upon the extinction of Pleistocene faunas (e.g. Barnosvsky and Lindsley 2010) and the domestication of camelids (e.g. Mengoni Goñalons 2008), some other subtler impacts have also had profound effects on animals and environments. For instance, humans would have also impinged upon wild camelid populations (e.g. L'Hereux 2008). All of these impacts can be more easily recognised and understood when the broader context at the continental scale and the long term are considered, including those instances that have been considered marginal in some regard.

Tony Legge was aware of the opportunities to learn about the human history with animals in the margins of the world, and he was very thoughtful and careful about the methodological aspects and the specific ways to gather information to answer the questions that concerned him. As to marginal areas, at least in biogeographical terms, the fact should be considered that accounting for the whole variation encompassed in them requires greater sampling efforts than sampling more central, smaller areas, and this requires systematic strategies. In this regard, doing research from the margins can be enlightening, as it can be a source of original questions in scientific enquiry. As Scheinsohn (2009) notes, research in the Periphery can be more flexible regarding theoretical frameworks than that in the Centre, thus favouring the articulation of different theoretical schemes (see Borrero 2004b for a discussion on related topics). Considering the environmental particularities of southern South America implies not just projecting the models elicited in other contexts, but reconsidering them and formulating brand new ones in the light of the specific conditions in this Neotropical region.

Finally, we would like to emphasize that whatever conception of marginality is applied, 'marginal' variability is as germane as any other for understanding our past (Muñoz and Mondini 2004). Or after Tony Legge's conclusion to his 2004 comments, even more so. As he masterfully put it:

'... to be "marginal" is to be pushing at the limits of human experience. Thus most of the major innovations in human history were, at their inception, marginal adaptations, from the first bipedal foot outside of Africa to the very beginnings of agriculture – both hazardous, marginal adventures at the outset, but ones that created the modern world. What began at the edge has become the very centre'. (Legge 2004, 120, emphasis in original)

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Zooarchaeology in Britain: a partial history

Dale Serjeantson

Introduction

Not long ago I had to read nearly 100 reports on animal bones from excavations in southern Britain as a preliminary to writing a review. The reports, which dated from 1929 to 2010, brought home strongly how much the reporting of animal bones has changed in the past 50 years. Since studying a bone assemblage for the first time in 1979 – under the supervision of Tony Legge from whom I learned so much about animals and hunting as well as zooarchaeology and research – I have seen and taken part in many of these changes. This is a brief account of some of them; it has the title ‘a partial history’ because it is inevitably incomplete and also because it is filtered through my own experience. Most of the examples cited here have deliberately been chosen to reflect research in the British Isles.

The changes took place in response to the changing intellectual climate in archaeology and the wider world. They have also been influenced by different national traditions of research, which until recently remained quite distinct. Some of these national traditions were defined by Sebastian Payne in a lecture at the Institute of Archaeology in London in 1985: he differentiated the ‘Cambridge school’ from the ‘German’, ‘French’ and ‘American’ schools. In North America zooarchaeology, like archaeology, has been rooted in anthropology and also in hypothesis testing. This has made anthropologists and zooarchaeologists in North America more explicit about aims and methods than is the tradition in Britain.

Some of the developments can be accounted for by changes in the scientific background and training of those carrying out the analyses. Until 30 years ago, animal remains were studied by individuals whose primary disciplines were palaeontology, geology, anatomy, zoology or veterinary medicine. The reports rarely contributed to archaeological questions. As Eric Higgs wrote in the Introduction to *Palaeoeconomy*, reports on animal bones written at the time were ‘a formal exercise with no particular purpose in mind’ (Higgs and Jarman 1975).

England has also seen major changes in the organisation of zooarchaeology. In the 1960s the study of animal bones was carried out by museums, a couple of university departments and individuals who were professionals in other fields. In the 1970s the Ancient Monuments Laboratory (AML), the in-house archaeological science laboratory of the Department of the Environment (later English Heritage and now Historic England), added animal bones to the materials studied within the laboratory. The AML also funded posts in Units located within some universities. The Unit employees were

required to provide a service, though that did not prevent some from also carrying out research. Since 1990, under a series of planning guidance statements, local authorities have been able to require property developers to commission the recording or excavation of archaeological features they were liable to destroy. Since then 'rescue' archaeology has been funded mostly by developers and carried out by commercial archaeological units, the largest of which now employ in-house zooarchaeologists. Over time, the number of university posts filled by archaeologists whose primary expertise is in the analysis of animal remains has greatly increased, as has the number of students studying zooarchaeology as part of an archaeology degree.

Palaeontology and geology

The earliest zooarchaeologists were nineteenth century palaeontologists who looked at the bones from Pleistocene caves in Europe in research that was closely tied to studies of human evolution. A Dutchman, a Dr Schmerling, has been credited with being the first person to appreciate the importance of animal remains. In the early decades of the nineteenth century he discovered and saved the bones of animals from caves in the Netherlands in order to investigate their age (Bahn 1999, 86). The zooarchaeological tradition in France and southern Europe derived directly from these early researches. As well as the preoccupations with evolution, French scientists studied extinctions and Pleistocene ecology and environment.

Zoology, veterinary science and domestic animals

In the mid-nineteenth century Danish 'kitchen middens' and Swiss lake villages yielded bone remains that led to studies of the first domestic animals in Europe. The zoological community gradually recognised the value of bones from prehistoric sites. The study of early domestic animals was a strength of zooarchaeology in Germany which focused on the breeds and types of the domestic animals, something that fitted the culture-historical approach of central European archaeologists. The practitioners were zoologists or veterinary scientists, of whom Joachim Boessneck and Angela von den Driesch, working within the Munich Veterinary School, were the most influential. Their research relied heavily on quantification and measurement and they were among the first to use indices as well as raw measurements; their standard set of measurements (von den Driesch 1976) was adopted rapidly in Britain and elsewhere. Von den Driesch wrote a history of veterinary science as well as an impressive number of studies of animal remains from Germany, Spain, Egypt and beyond. Analyses contained restricted interpretation in anthropological terms, a result of the veterinary bias as well as a general reluctance to over-interpret archaeological finds. In Britain Frederick Zeuner pioneered research into the origins of domestic animals with a seminal meeting on cattle domestication held at the Institute of Archaeology in London (Zeuner 1963). This research has continued (Clutton-Brock 1981). It originally relied mainly on measurements (e.g. Grigson 1969) but in the last two decades it has gained a renewed impetus with the application of DNA analysis (e.g. Edwards, Bollongino *et al.* 2007; Larson *et al.* 2007).

The first archaeologist in Britain to recognise the importance of animal bones from later prehistoric archaeological sites was Augustus Lane Fox Pitt-Rivers. For the report on his excavations at Cranborne Chase, he arranged for sheep of different breeds to be slaughtered so that he could compare the Bronze Age bones with modern sheep (Pitt-Rivers 1892). In the early twentieth century palaeontologists such as Wilfred Jackson, who were based in museums, studied bones and from the

1950s onwards veterinary scientists developed an expertise and interest in identifying bones from archaeological sites. Perhaps inevitably, some found that the most interesting elements of the assemblage were the pathological specimens. In the report on the bones from the the Knap of Howar in Orkney, Barbara Noddle wrote ‘The most interesting specimen was the humerus of a newborn calf exhibiting classical signs of chondrodystrophia’. Michael Ryder, who was an animal scientist at the Dick Vet School in Edinburgh, studied the bones from excavations in Yorkshire because ‘despite numerous medieval records of sheep numbers, there was little to indicate what the sheep had been like’ (Ryder 1969). Arguably, Ryder’s more important contribution to archaeology came in his later research, in which he developed expertise in identifying ancient wool, hair and other fibres.

Until the 1970s reports were usually printed as appendices. The limitations of their zoological focus are well demonstrated by the comment on the bird bones from the Viking site of Jarlshof: ‘Fragments of bird bones were quite numerous. Apart from the age of the deposits in which they were found, they are not of further interest, as all are recorded from Shetland today’ (Platt 1956). This, despite the rich and continuing ethnographic tradition of seabird fowling in the north and west of Scotland!

Environmental archaeology

The study of animal bones as a means of interpreting early environments was the rationale behind the setting up of a course at the London Institute of Archaeology in the 1930s, led by Zeuner. Initially ‘geoarchaeology’, it was renamed the Department of Environmental Archaeology in the 1960s. Animal bones were treated as providing information on the human environment. When Tony Legge was appointed to head the archaeology section of the Extra-Mural Department of the University of London (Sheldon, this volume) he obtained agreement to introduce a new course called ‘Environmental Archaeology’, but in reality 90% of the course was devoted to human palaeoeconomy as practised in Cambridge. It was only after the appointment of Professor David Harris that the focus at the Institute changed to how humans made a living from their environment, rather than the effect of humans on the environment. A legacy of the location of faunal studies within ‘environment’ was that reports on animal bones began to be included within excavation reports, but were included in a chapter on ‘The environment’. This practice continues – despite the fact that the animal remains also provide insights into many other aspects of human life.

Palaeoeconomy at Cambridge

Zooarchaeology in Cambridge began in the 1960s. The first PhD student to publish on prehistoric animal husbandry was Charles Higham, as he describes in this volume. The title of his first publication, ‘Stock rearing as a cultural factor in prehistoric Europe’ (Higham 1967), summed up the new direction for animal bones: they could provide *cultural* as well as environmental and economic information. Zooarchaeological research in Cambridge took off from 1968 onwards with the British Academy Major Research Project in the Early History of Agriculture, directed by Eric Higgs. Higgs and his team set out to show that animal bones could provide information on how animals were hunted and managed in the past during the period of the transition to agriculture. For the first time in Britain explicitly archaeological and anthropological objectives were pursued through the study of bone and plant remains.

A very important advance of the Early History of Agriculture Project was in pioneering of new

methods of analysis. Researchers published articles on methods of identification, quantification and interpreting age at death and sex ratios. Just as important was the insistence on retrieval. Excavators were encouraged to recover bones in a scientific manner, which involved sieving the sediments (Barker 1975). Sebastian Payne carried out an experiment on the effects of sieving (Payne 1972), known to nearly every zooarchaeologist, which showed the elements that were missed when sediments were not sieved. They include individual teeth and unfused epiphyses, crucial evidence for age at death. As Tony Legge (1978) wrote, the failure to sieve was something that ‘will puzzle any worker familiar with the methodology of any science’. The need for sieving had been stressed by the Project from the beginning. In the 1960s Iain Crawford, about to excavate the settlement of the Udal in the Outer Hebrides, visited the Bone Room in Cambridge to ask advice and was told by Tony Legge to ‘sieve everything’. His excavation was consequently the first in Scotland to employ sieving. The history of the fishing industry in northern Europe has been rewritten since bulk sieving became routine on Scottish sites (Barrett 1997). In the 1970s the Environmental Archaeology Unit in York devised a method for bulk-sieving the recalcitrant sediments within that city. Since then the practice of bulk sieving or extensive sampling has spread on excavations in Britain, though slowly.

A new method of quantification was embraced by researchers of the Early History of Agriculture Project, the use of Minimum Number of Individuals (MNI), a measure that originally came into use in North America. Arguably the most important methodological contribution of the Project was the use of age at death to interpret animal husbandry (Ewbank *et al.* 1964, Higham 1967; 1968). The illustrations of wear stages on the teeth of sheep, cattle and pigs published by Payne and Annie Grant (Payne 1973; Grant 1975) have been used almost universally for recording; however establishing how tooth eruption and wear and bone fusion relate to age has been problematic. The handy and accessible tables that were published by Silver (1963) have been – and continue to be – routinely referred to even though they have subsequently been shown to be inaccurate. The ages of eruption and fusion he quoted were based on the veterinary textbooks of the day; those for ‘early’ or ‘unimproved’ and modern breeds have often been cited by zooarchaeologists, but they were taken from nineteenth century publications subsequently shown to be wrong, as Payne demonstrated (Bull and Payne 1982; Payne 1984). Tony Legge continued to research cattle and pig ageing throughout his life, adding refinements such as crown height and pillar wear; his contribution to cattle ageing is discussed in detail by Gillis (this volume).

Researchers in the Early History of Agriculture Project were also the first to show that – as well as showing size changes resulting from domestication – measurements could reveal the ratio of the sexes in the population of hunted or herded animals. In order to demonstrate size and shape of a population individual measurements were required, but these were rarely published at the time. Zooarchaeologists in Britain fought long and hard for their publication with the Ancient Monuments Laboratory among the first to publish these in their ‘grey literature’ Ancient Monuments Reports; a few well-funded excavation reports did the same. Over the years this battle has to some degree been won, but, like many battles, the need is no longer so great today because measurements can be made available digitally on demand or in archives. Researchers have continued to develop increasingly sophisticated metrical analyses (e.g. Rowley-Conwy 1998). However, as Umberto Albarella (2002) pointed out, the ‘homogenisation of bioarchaeology training’ which has taken place as zooarchaeology is increasingly taught within the discipline of archaeology has led to the danger of a loss of expertise in metrical analysis’.

Research in Cambridge transformed zooarchaeology in Britain and had a major influence in other countries. The methods, though devised originally for the Near East, have continued to be applied to later prehistory and the Early Historic period in Britain and elsewhere. The interpretations have

broadened the scope of what could be said about hunting strategies and, most importantly, have shown that it is possible to reconstruct how farmers managed their animals in order to keep their community supplied with food throughout the year. These aims were anthropological and archaeological. Tony Legge summed this up in a symposium in 1977 at the Institute of Archaeology in London where he argued that we should all be studying ‘zooarchaeology’ rather than ‘archaeozoology’ (Legge 1978).

Taphonomy and processualism

Taphonomy, a term coined in the 1940s that applies to the processes that intervene between the death of an animal and the appearance of a fossil or bone fragment on the analyst’s desk, was ‘discovered’ in Britain in the early 1980s with the publication of *Ancient Men and Modern Myths* (Binford 1981). We all learned to recognise traces of carnivore gnawing on bones, to distinguish butchery marks from accidental damage, green fractures from dry bone fractures, and to see and interpret cut marks. In 1935 Jackson could write ‘Unfortunately nearly all the bones were broken’ and ‘few bones were perfect’ when confronted with the animal bones from the Stonehenge excavations (Kennard and Jackson 1935). *Of course* the bones were broken: they were a typical archaeological animal bone assemblage. The nature and degree of butchery, breaks and gnawing are themselves cultural information.

Lewis Binford was far from being a pioneer in the study of cut marks. In 1831 the palaeontologist Tournal had been impressed by the ‘apparently human cut marks found on some fossil animal bones’ from the caves in the Aude valley and even experimented with flint and metal knives (Bahn 1999, 83). Those who worked on the early Danish Kitchen Middens in Denmark also understood the importance of bone modifications, but their insights were not followed up in Britain for many years. Just as important as the interpretation of butchery marks and marrow extraction was Binford’s clarification of expected survival of different parts of the skeleton, following from earlier research in South Africa (Brain 1967). Binford’s work confirmed that bone survival was density-dependent and that jaws and teeth survive better than other parts of the skeleton (Binford and Bertram 1977). Tony Legge published one of the first graphs to show relative numbers of anatomical elements according to expected survival. He demonstrated – from the fact that relatively few jaws were present – that the cattle at the Neolithic site of Hambledon Hill had not been killed within the enclosure but that parts of the carcass had been carried there from elsewhere (Legge 1981, fig. 3). Though carnivores, in practice usually domestic dogs, were the main cause of attrition of bones, in due course it became clear that equifinality was in operation (Halstead 1998): whether the cause of damage was carnivores, marrow extraction, trampling, post-burial degradation or a combination of these, the end result was a similar pattern of element survival.

Historical zooarchaeology: complexity, status and crafts

From the late 1970s onwards it became clear that the focus of the Cambridge School on food production and animal husbandry was too narrow to serve as an interpretive framework for many of the bone assemblages that were being recovered from complex sites throughout Europe and Asia (Barker and Gamble 1985). In Britain the large number of sites being excavated in advance of construction and development, towns, abbeys, castles and Roman villas, called for more nuanced interpretation.

The 1980s saw major excavations in medieval towns including Southampton, Lincoln, York and London. The animal bones were studied in Units (Bourdillon and Coy 1980; O’Connor 1982; 1991;

Rackham 1994). The towns were not – or not necessarily – sites where food was produced; rather, they were places where food was consumed and where foodstuffs and animals were brought from elsewhere. Despite this, the animal foods that people ate did reflect agricultural production: it can be seen in the changes in the relative numbers of the domestic animals, and in gross changes in animal size and in age at death (Grant 1984; Albarella 1997; 1999). Urban excavations raise questions of scale and also of the integrity of deposits. It is normal for towns to contain sequences of deposits from all periods, which means that there are problems of residuality. In the 1980s the process of dealing with assemblages of mixed date began to be formalized by the introduction of preliminary assessment. The pottery provided a guide to contexts that contained residual material, including bones, from earlier periods and such contexts could then be omitted from the analysis.

Complex sites also raise urgent questions about the origin of each deposit. Was it from a local individual household? or from a working area? or redeposited from elsewhere? If the former, was it mainly food waste? or specialised butchery waste (Maltby 1989)? or craft waste (Serjeantson and Waldron 1989)? Until the nineteenth century specialised butchery and craft working took place in towns and other central places and many relied on animal products: wool, hides, skins, furs, bones, feathers and oils. Craft workers, especially those in the more noisome crafts, were illiterate so it has fallen to archaeology and zooarchaeology to tell the stories of those who boiled bones for oil, knackered horses or procured cats for their skins or food (Serjeantson 1989; Wilson and Edwards 1993; Luff and Moreno-Garcia 1995).

Bone assemblages from historic times cannot be interpreted solely in the light of anthropological theories of animal husbandry, but have to be discussed in the light of economic history. This problem was been faced in the ancient Near East, Egypt and Greece (e.g. Halstead 2003), where there are visual or written accounts. Some researchers in the British Isles tackled both animal bones and original historic records (McCormick 1983; Biddick 1989) but most have opted for actual and virtual dialogues between historians and archaeologists (e.g. Woolgar *et al.* 2006).

Social zooarchaeology

In their contribution to the symposium ‘The Bone Room’s Past’, Annie Grant and Graeme Barker recalled how Higgs used to claim that the study of societies later than the Neolithic was ‘froth’ (Smith 2013). Grant chose to study ‘froth’ when she embarked on the massive assemblage from the Iron Age hill-fort of Danebury. While the Cambridge School was arguing that economic behaviour was rational and, in the long term, adaptive, Grant showed that the deposition of bones in some pits at the hillfort of Danebury was not the random discarding of waste food, but a deliberate act that reflected the beliefs of Iron Age society (Grant 1984). Since then many others have shown how certain deposits have their origins in individual and community rituals. In the case of animal bones included with interments and cremations, the interpretation of the remains as part of burial ritual is clear (e.g. Bond 1996) but other deposits from all periods from Neolithic to Anglo-Saxon times have since been interpreted as ritual (e.g. Davis and Payne 1993; Hamerow 2006; Serjeantson and Morris 2011). Richard Bradley (this volume) draws attention to Tony Legge’s interpretation of the bones in the Late Neolithic pits beside the Dorset Cursus: he had observed that, based on their taphonomy and selection, the bones had been deliberately collected for burial.

Studies of food production, nutrition and diet were mid-twentieth century preoccupations as the developed world questioned how to produce enough food to feed the world’s growing population. From the 1990s onwards however pre-occupations changed to the study of the social rather than the economic significance of food. The consumption of communal meals and especially feasting marks

social cohesiveness and identity at the same time as keeping people alive. In ranked societies the elite could invoke choice in the foods they ate. In Medieval England certain foodstuffs, especially game, wildfowl and some fish, were reserved for the upper classes, so their consumption in castles and monasteries was a sign of wealth and status (e.g. Albarella and Davis 1996; Sykes 2004).

It became intellectually legitimate to discuss food consumption as well as food production in early agricultural as well as historic period societies. In particular it was observed that communal gatherings and feasting have been a feature of prehistoric as well as historic period settlements (e.g. Albarella and Serjeantson 2002; Legge 2008). In an English Heritage policy document *Science in Archaeology: an Agenda for the Future* the subject of study is 'food' rather than animal husbandry and hunting (Legge *et al.* 1998).

The consumption of certain foods is a mark of not only of status but also of ethnicity. A number of studies have sought Jewish identity in the rejection of pork and shellfish in the Near East and also in Europe: food remains from Amsterdam revealed ethnic differences between households (Ijzereef 1989). Finbar McCormick (1991) identified the influence of Viking and Norman invaders in Ireland and Naomi Sykes successfully disentangled Norman identity and influence in the animals and food across the period of the Conquest in England (Sykes 2007).

Such studies of ritual, food, feasting and ethnicity were among the characteristics of what has come to be called 'social' zooarchaeology (Marciniak 2001; O'Connor and Sykes 2010; Russell 2012). This originated in the 'social archaeology' that became increasingly popular in the 1980s. One of its theoretical precursors was post-processualism. When applied to zooarchaeology post-processualism sought the particular rather than the general, the individual act or meal rather than the universal laws that govern food production and bone deposition. In Britain it was taken up by theoretical archaeologists but was never favoured as much by zooarchaeologists, rooted as they were in scientific method. More recently some zooarchaeologists as well as anthropologists have been influenced by the transformation in peoples' attitudes to animals over the past 30 years that ultimately derives from the ideas of the animal rights movement. They have argued for the 'animal turn', putting animals themselves at the heart of the discussion and for a 'non-anthropocentric approach to animal bones' (Armstrong-Olson 2010; Overton and Hamilakis 2013).

Discussion

Revealing as some of the new theoretical approaches in zooarchaeology are, many of the most important recent advances in the study of early human activities have come from the techniques of scientific analysis developed over the past 30 years. The study of DNA, lipids in pottery, blood traces on stone tools, and isotopes and trace elements in bone are increasingly complementing traditional zooarchaeological methods (e.g. Outram, this volume). DNA studies have superseded bone analysis in pinpointing the origin and relationships and hence the origins of domestic and wild animals. Isotopic analysis of bones and teeth allows us to examine life histories of animals as well as human mobility.

Today the theoretical and methodological advances begun by the Cambridge School and the taphonomic insights of the 1980s are taken for granted and used by every zooarchaeologist. In a volume dedicated to the memory of Tony Legge it is good to be able to record that the influence of the Cambridge tradition and Legge himself is still strong. This is confirmed by the very fact that those who claim that they are doing 'social' zooarchaeology continue to re-affirm the novelty of carrying out research 'beyond subsistence' (Overton and Hamilakis 2013).

National traditions of research have also converged in the past 30 years. International meetings have proliferated, more and more publications are in English, and the World Wide Web has made it

easier to read work published anywhere in the world. The insights based on remains of animals have at last begun to be an integral part of the accounts of excavated sites and to contribute to understanding individual human activities as well as wider trends in food and husbandry. It is a truism that zooarchaeology is defined not by an overarching theory but by the material studied. It been a great virtue of the discipline – and what makes it fun – that its practitioners, whatever their original discipline, have to acquire expertise in many fields. As well as zoology and archaeology, zooarchaeologists have to know about animal and human behaviour, anthropology, agriculture, husbandry, butchery, ecology, economy, history, hunting, geography, mechanical properties of bone, nutrition, sociology, subsistence economics and more. Zooarchaeologists have to remain open to using new scientific techniques as well as new theoretical approaches as the range of subjects their material can address becomes ever broader.

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Part III

The zooarchaeology of milking controversy

Calf mortality and milking: was Tony Legge right after all?

Paul Halstead and Valasia Isaakidou

In the year when Sherratt (1981) proposed that domestic animals in South-west Asia and Europe were initially managed for meat and later for milk and other ‘secondary products’, Tony Legge (1981a) argued that high levels of infant calf mortality at Bronze Age Grimes Graves in eastern England implied management of adult female cattle for milk. In identifying similar calf mortality in the earlier Neolithic of the north Alpine margins, where later prehistoric assemblages exhibited older slaughter more consistent with exploitation for meat, Legge proposed the opposite temporal trajectory to Sherratt, but placed explanatory emphasis on local environmental conditions rather than diachronic advances in animal husbandry. While Sherratt’s model drew some approval from prehistorians, Legge’s argument, and his similar interpretation of more indirect cattle mortality data from Neolithic southern England (Legge 1981b), was immediately and repeatedly challenged by zooarchaeologists, principally on the grounds that cows of primitive breeds will not let down milk in the absence of their calf (e.g. Clutton-Brock 1981; Entwistle and Grant 1989; McCormick 1992). True to character, Legge stood his ground (1981c; 1987; 1989; 1992).

One of us (Halstead 1998), drawing largely on ethnographic information from Greek herders of sheep and goats and secondarily on British sources dealing with cattle, subsequently argued that reluctance to let down milk is more common in livestock stressed by poor diet or unfavourable temperatures and can be overcome if herders invest sufficient effort in coaxing difficult animals. Indeed, ethnographic and historical accounts of reluctant let down list some remarkable counter-measures (e.g. stuffing the dead calf’s hide, smearing a surrogate calf with the adoptive mother’s dung, or ‘cow-blowing’). Balasse (2003) responded that cattle, especially those of non-dairy breeds, have a much lower proportion of their milk in easily accessible cisternal (as opposed to less accessible alveolar) storage than sheep and goats and that, accordingly, cows of ‘primitive’ breeds, such as the Salers and Aubrac of upland central France, cannot be milked in the absence of their calf. In consequence, some zooarchaeologists now accept high levels of infant mortality as optimal for milk production in sheep and goats, but treat a peak of mortality around the end of lactation (‘post-lactation slaughter’) as the hallmark of milking in cattle (e.g. Balasse *et al.* 2000; Vigne and Helmer 2007).

This contribution begins with a critical evaluation of Balasse’s argument, *inter alia* highlighting the dangers of treating traditional cattle breeds from agriculturally marginal regions as representative of early domesticates. The second section presents original oral-historical data on management of

traditional, unimproved cattle in early and mid-twentieth century Greece. In conclusion, we argue that Tony Legge's original thesis was essentially correct.

The management of Salers and Aubrac cattle in upland central France: changes and contradictions

Balasse (2003, 5) reports that '[I]n the case of the Salers and Aubrac cattle breeds, it is simply impossible to get the milk without the presence of the calf.' These breeds from the French Massif Central are typical upland cattle, characterised by resilience to harsh conditions more than high productivity in milk or meat, but they may be misleading models for early European domesticates. The Salers was subject to selective breeding, for conservation and improvement, from at least the early nineteenth century (Grogner 1831; Durand 1946, 210–211), and the establishment of herd books for the Aubrac in 1894 and the Salers in 1908 (Jussiau *et al.* 2006, 126 table 6.1) presumably involved further selection of 'ideal' characteristics. For example, the ideal reddish colour of Salers cattle may have become more standard over the last century and Aubrac cattle exhibit significant changes in colouring and conformation over this time-span (Rousseau and Dubois 2011). Moreover, rearing of both breeds in the nineteenth century primarily for labour and to a lesser extent milk (e.g. Grogner 1831) has given way during the twentieth century to dual exploitation for milk and beef (Durand 1946, 213, 220–221) and latterly to production mainly of beef. In sum, although unquestionably rustic, Salers and Aubrac cattle have been subject to significant changes over at least the last two centuries in appearance, management goals and performance and cannot uncritically be accepted as proxies for early domesticates.

Despite changing management and thus selective pressures, herders of Salers cows around Salers itself and of Aubrac cows further south around Chaudes Aigues, interviewed in 2008, believed that their early twentieth century forebears had also faced problems with let down in both breeds and that milking in the presence of the calf had long been the norm. Nonetheless, the statement that Salers and Aubrac cows cannot be milked in the absence of their calves, although widely repeated by both scientists (e.g. Martinet *et al.* 1999) and herders, must be qualified. Interviewees on the Massif Central reported that young cows milked for the first time posed the greatest problems of let down, as also noted in the scientific literature (Bruckmaier 2005, 270), and responded poorly to measures adopted (mostly in the past) following loss of a calf: clothing a substitute in the dead calf's skin (Salers and Aubrac), putting salt on a substitute calf to encourage licking by the cow (Aubrac), stroking the cow to mimic the calf (Aubrac), confining the cow with a substitute calf so that the latter suckles and takes on a familiar scent (Aubrac), and blowing into the cow's vagina (Aubrac). These measures were evidently fairly commonplace a few decades ago and, with the exception of cows calving for the first time, seem to have been reasonably successful. Indeed, for the early nineteenth century around Salers, Grogner (1831, 33–37) reports that it was normal practice in larger herds (of 20 or more cows) for many calves to be slaughtered 2 weeks after birth and for those retained each to be suckled by two, three or even four of the cows milked for cheese production. The availability of pasture determined how many calves were retained and raised to adulthood – the females as replacement cows and especially the males for sale as draught animals – and Grogner does not mention problems of let down among cows deprived of their own calf. Presumably, since the early nineteenth century, either Salers cows have been selected for reluctant milk let down or, perhaps more plausibly, changes in the relative value of milk/cheese and meat or in the availability of human labour have made herders less willing to invest the effort necessary to overcome any such problem. Either way, milking an Aubrac or Salers cow in the absence of her calf

is *not* impossible and, in the presence of a substitute, perhaps not even difficult.

Balasse's point of departure is that cows have only a small proportion of their milk in accessible cistern storage (and the long-term effect, if any, of human selection has presumably been to enhance this proportion). Suckling calves indeed seem able to exploit more fully the less accessible alveolar stores than can human milking (e.g. le Neindre *et al.* 1976) and rustic cows such as the Salers are less willing than specialist dairy breeds to let down in response to stimulus from herders rather than their own offspring (Martinet *et al.* 1999, 362). Delayed slaughter of prehistoric calves, therefore, may well have enabled more thorough exploitation of the milk-producing potential of their mothers than culling soon after birth. We have no *a priori* grounds, however, for assuming that prehistoric herders wished to maximise total milk extraction rather than the availability of milk for human consumption or perhaps to minimise the associated labour costs of herding, providing shelter or collecting fodder. As argued elsewhere (Halstead 1998), maximising models are invaluable heuristic tools, but a problematic basis for predicting past human behaviour. The importance of variable husbandry priorities in shaping how cattle are managed is further highlighted by oral-historical evidence from Greece.

Managing unimproved cattle in Greece

In Greece, sheep and goats have traditionally dominated dairy production. In the first half of the twentieth century, the indigenous 'wild' (i.e. un-improved domestic) cattle of Greece were widely used for ploughing, while sale to urban butchers of any calves not needed as replacement draught animals could provide a significant cash income. Milk production from cattle expanded following introduction from the 1950s onwards of dual-purpose (milk/beef) Swiss Braunvieh and later of specialised dairy Holsteins (Georgoudis *et al.* 2003). A few wealthy landowners introduced improved dairy cattle from abroad a little earlier, but high maintenance (especially before widespread adoption, also post-war, of industrial fertilisers) and capital costs largely prevented wider dissemination. The indigenous cattle were regionally variable in appearance, size and to some extent productive qualities (e.g. Kugler 2010), but had overwhelmingly undergone far less selection for milking over the previous century (and almost certainly much longer) than the Aubrac and Salers of the Massif Central. Although also perhaps problematic as models for prehistoric domesticates, therefore, indigenous Greek breeds may shed useful light on the feasibility of milking rustic, non-dairy cattle.

Rearing cattle in early and mid-twentieth century Greece was rather easier in the cereal-growing lowlands of the north than in the more arid south, where suitable pasture was sparse and short-lived and where cultivated stall-fodder – even cereal straw – was scarce. Both ownership of draught cattle and rearing of calves (as replacements for the yoke or for sale) were much more commonplace, therefore, in northern than southern Greece. For similar reasons, milking of indigenous cattle was not unusual (if clearly secondary to dairy exploitation of sheep and goats) in northern Greece, but rare in the south. Here we examine informants' accounts of managing indigenous cattle – especially whether, how and why cows were milked. For the sake of brevity, we focus on the southern island of Kythera and the Pieria lowlands of northern Greece.

Kythera

Most elderly (octogenarian and older) informants from villages on Kythera declared that indigenous cows were not milked. Many did not have a cow to milk because they had too little land to support more than a donkey and the odd house-goat or -sheep. Some cultivated sufficient land to warrant ploughing with draught cattle, but used bought castrated male oxen rather than self-reproducing cows,

variously attributing this to scarcity of pasture, human labour or byre space. Others owned, but did not milk, cows. For example, Vretos in Fratsia for many years kept two small indigenous cows that ploughed and worked on the threshing floor, and each bore one calf per year for sale, while stall-fed only cereal straw to supplement seasonal grazing. They had ‘udders like a goat’ and could not suckle their calves for more than 2–3 months. They had so little milk that ‘nobody milked them even if the calf died young’, relying instead on sheep and goats for dairy produce. Later he acquired multi-purpose Kean cows (an improved rustic type) that worked as well as the local breed, bore bigger calves with more meat, and also produced more milk than the latter needed so that they could be milked while suckling for 5–6 months. A Kean cow could usually be milked even if she lost her calf, although a few were reluctant to let down. Thodoros, as a teenager in his father’s household in Aroniadika, ploughed with oxen, but following marriage in the early 1950s switched to cows that could also produce calves for sale as yearlings to compensate for his modest landholding. His cows were of local breed, small enough to plough unhindered under olive trees and able to survive on a very sparse diet, unlike his neighbour’s two Kean cows that died from under-feeding. Thodoros never milked his indigenous cows and regarded this as the norm. His wife Georgia, however, had as a girl watched an uncle stroking a cow from the neck down to the udder as a prelude to the unfamiliar experience of being milked because, after sale of her calf, she was producing too much milk to dry off safely unaided. Thodoros and Georgia did not emulate the uncle, but they had sufficient dairy produce from their sheep and goats and valued large calves (suckled for three to four months) more than an increased milk supply, perhaps partly because Georgia’s one attempt to make cheese with cow’s milk had been a failure. Likewise, Stavroulla from Pitsinianika had not milked cows because she had enough sheep and goats for this purpose, while Titika recalled that cows were not milked in the villages around Karavas, because their milk was reserved for fattening calves to sell.

In Mitata, Stefos recalls that his father ploughed with an ox and a cow, both of local breed, and that the latter each year bore a calf that she suckled for at least five or six months. Nobody, he claims, milked such cows ‘not even if the calf died – the cows were not accustomed to it and would not stand for it’. Nonetheless, at least one neighbour, Foteini, did milk her small indigenous cows. Her first she acquired as a young calf, that she petted and fed by hand, but another acquired as an adult from Fratsia let down milk in response to the presence of Foteini or her husband, even with her first calf. These cows had a small udder but were well fed and, after suckling for 1.5–3 months until the calf began to graze, were then milked for two to three months without the presence of the calf, although they dried up sooner if yoked to the plough. Foteini mixed their milk with that from her sheep and goats, to make cheese for the family. Irini grew up with an uncle in Vouno (near Karavas where Titika saw no indigenous cows being milked). The uncle reared calves for sale both as future draught oxen and for meat. His calves suckled for two or three months, until they could graze or eat dry fodder, and were sold at five or six months, after grazing outdoors over summer, or sooner, if winter approached and byre space was limited. If the cows had a lot of milk, he took whatever the suckling calves left, but he mainly milked after weaning and, with the calves initially present in a separate pen within the byre, did not experience major problems with let down. Like Foteini, he mixed milk from cows and sheep to make cheese. He and Foteini were unusual on Kythira in milking indigenous cows, but not exceptional. As Stratis from Potamos recalls, however, those who milked the old Kythiran cows were few and the practice was unknown to most.

Pieria

In north Greek Pieria, milking of indigenous cows was more widespread, but not universal, while

traditions of animal husbandry also differed between cultural groups such as Thracian refugees from European Turkey, Pontic refugees from north Anatolian Turkey, and 'locals' already resident in the region. Takis from the 'local' township of Kolindros was a young child in the early 1920s when the refugees settled in neighbouring villages. His father had enough land to support draught oxen (castrated males), while his indigenous cows produced calves that he either retained as replacement oxen or sold to the butcher at one or two years of age, depending on his need for cash. 'Because we had milk from our sheep, we did not put a hand under the cows, but left the calves to consume their milk and grow faster.' Takis also considered that cow's milk made poor cheese and later, as head of a household without sheep and despite having a cow that produced more milk than the family could drink, he bought cheese from a herd of goats. Conversely, his neighbour Andreas grew up in a household that owned only two donkeys and three or four goats, of necessity relying on the latter for dairy produce.

In general, the poorer 'locals' in Kolindros did not own cows, while at least some of the better-off also owned sheep that yielded richer milk preferred for both domestic consumption and sale. Nikolaos' father, however, who owned four oxen but no sheep (perhaps because his sons were too young for herding), milked his five or six indigenous cows kept primarily to rear calves for sale as adult (3–4 year old) cows or oxen. He milked after weaning at 5–6 months, but started sooner if a cow produced more than her calf consumed. All his cows were reluctant to be milked and initially he let the calf suckle two teats, while he milked the other two. Some kicked, spilling the milk, and had to have one leg tied to a post during milking. The family consumed most of the milk fresh or as yoghurt, but his father also made cheese when the supply was particularly abundant. A few years later as a husband and father, however, Nikolaos kept sheep as well as cows and relied on the former for dairy produce, leaving the latter to suckle their calves which thus grew bigger and were sold at a higher price.

Elderly 'locals' in surrounding villages had similar childhood experiences of indigenous cows. In Livadi, Lefteris' father kept as many as 10–15 oxen and cows and no sheep or goats, but did not milk his cows, preferring to raise bigger calves for sale. In Paliambela, Giorgos' father had 100 sheep, which supplied dairy produce for consumption and sale, and a handful of cows, whose milk fattened calves for sale; when he switched to higher-yielding cows, sired by a Swiss Braunvieh bull, he acquired infant calves for fattening from Pontic refugees (below). A neighbour, Manolis' father, had no sheep and fewer indigenous cows that provided draught for the plough, calves for sale, and milk for the family. He let the calves suckle for one or two months and then fed them milk from a bucket, supplemented by alfalfa hay. Manolis recalls that a few of these cows were easy to milk, and let down milk even after losing a calf, but most were difficult and some again needed to be hobbled to prevent them kicking during milking.

Most Paliambela residents were Thracian refugees, who arrived overland in ox-carts, some accompanied by the odd cow or buffalo, but few by smaller livestock. Their distinctive culinary tradition made greater use of milk from cows and buffalos. Mitsos was aged 3 on arrival. His father, then a new household head, only had his two oxen, but in Paliambela was given a female buffalo by his father-in-law and bought an indigenous cow, both of which provided calves for sale and milk for domestic consumption. The cow calved every second year and, while suckling, gave a litre or two of milk per day that the family mixed with that from the buffalo to drink or make into butter. In their 'homeland' the Thracians considered cow (and buffalo) milk superior to that from sheep for butter, but regarded cow milk as inferior or even wholly unsuitable for cheese. In their early years in Paliambela, however, most did not have sheep and consequently made cheese from buffalo milk (if available) or otherwise cow milk, although that made by Mitsos' mother-in-law apparently spoiled in hot weather.

Koula's father, who arrived in Paliambela as a teenager, gradually built up a flock of sheep before marriage in the early 1930s, when he trained two young draught oxen and his wife brought a

young heifer, daughter of a cow that had walked from Thrace. The young cow calved every year and, for an unimproved animal, milked well. Over the following years, they accumulated six female buffalos and ten cows, which again produced calves for sale and milk, which they mainly used – unmixed – to make two types of butter for sale and to provide fresh milk and cheese for domestic consumption; her father did not use the milk from his sheep for cheese, because he could sell it to a local dairy. While some Thracian neighbours weaned later and took less milk to rear bigger calves with tenderer meat, Koula's parents milked their cows after weaning the calves earlier at 2–3 months. Their indigenous cows were much less demanding of fodder (although, unlike many in southern Greece, they received grain supplements), much less productive, and much harder to milk than the improved breed that Koula and her husband kept in later years. Her parents routinely used the calf to initiate let down in the former, but Koula's statement that, 'if you did not let out the calf to butt the cow, you did not see any milk', involves some dramatic licence. Switching from the general to the particular, she also describes one particular indigenous cow that could under no circumstances – even with a full udder – be coaxed or tricked into letting down milk without her calf. By implication, it was difficult rather than impossible to milk their other relatively pampered indigenous cows without the calf being present; in practice, Koula's parents must have faced this difficulty rarely, if ever, since they retained their calves long after weaning and never lost one at or shortly after birth. It is instructive to compare her experiences with those of Mitsos. He started married life with only two indigenous cows that worked, calved and provided some milk and he never achieved more than one or two additional cows for calves and milk. He took a little milk to drink fresh while the calves suckled. He too weaned the calves at around 2–3 months old and then kept them apart from their mothers in the same byre, allowing him to take all the milk and also make butter. His cows varied greatly in how easily they let down – one kicked so much that she was never milked, but she was an excellent draught animal and produced calves, so he retained her. The rest he milked, however, without untying their calves, although patience was needed – especially with those calving for the first time. He insisted that, if a cow lost a calf, she could be coaxed to let down by washing her udder and then stroking her. Mitsos and others with very few cows had the time and incentive to coax let down and invested the necessary effort in encouraging reluctant cows. Those with ten or more cows, however, like Koula's parents, had neither the time nor the need to coax reluctant individuals and often describe indigenous cows as impossible to milk in the absence of the calf.

By common consent, the simplest way to induce let down in unimproved cows was to allow the calf to head-butt its mother's udder, but many informants noted that, as the calf grew bigger and stronger, its attentions became increasingly irksome and tiring. Koula's parents weaned calves early both to take more of the milk for their own use and to improve the cow's well-being and productivity. Likewise, Mitsos once had three cows give birth in 10 days and he removed the calves immediately for bottle- and then bucket-feeding. He gained much more of the first 2-3 months of lactation, but also found that the cows were less tired and produced perhaps 3 litres of milk per day more than they did normally. The calves grew more slowly, but he did not repeat the experiment primarily because early hand-feeding was very time-consuming.

For this reason, when 'local' Giorgos and Thracian Thanasis fattened others' unwanted calves to use up surplus milk from their cows that the dairy would not take, they acquired calves 30–40 days old that could drink from a bucket. These calves came from villagers of Pontic refugee origin, for whom milk, butter, cheese and yoghurt were of great culinary significance and many of whom – for cultural and practical reasons – did not keep sheep and so wished to milk their one or two cows intensively. The first generation of Pontic refugees, having fled by sea and largely empty-handed, of necessity raised unimproved cattle of 'local' or possibly Thracian origin. At Nea Trapezounta,

Anastasios and Zoi, two neighbours in their 90s, used to separate such calves at birth, feeding them with their finger ('like a teat') and then from a bucket until weaning or slaughter at 40–50 days old, when their meat was edible, but they recall Zoi's grandfather discarding carcasses as inedible at birth. They milked their indigenous cows almost immediately after calving (once the first colostrum had given way to 'clean' milk). To encourage let down, they stroked or sang to some cows. Others kicked unless they could lick their calf tied in front of them, but usually were accustomed to milking by the time the calf was slaughtered or could be satisfied by stuffing its hide with straw 'like a scarecrow' (a ploy also used if a calf died prematurely). Any cow that did not respond to coaxing went to the butcher, but both milking of cows and control of calves were easier if the latter were removed at birth. Milking was also easier if cows were warm and well fed.

Milking unimproved cows in Greece

Greek farmers of the early and mid-twentieth century kept indigenous cows for draught, to produce replacement breeding and working animals and calves for sale to urban butchers, and in some cases to provide milk for human consumption. These regionally variable cattle had been selected for tolerance of poor diet and hard work rather than capacity to produce or willingness to let down milk. Elderly informants, especially in southern Greece, routinely declare that unimproved cows were not milked because of their limited productivity and/or reluctance to let down milk except for their own calves. Closer enquiry, however, reveals that such cows, although producing much less milk and letting down more reluctantly for human milkers than well-fed cows of improved dairy breed, were quite widely milked – even in southern Greece. Milking and suckling of the calf were often combined, but variously because large calves were at least as high a priority as milk for human consumption, and/or because the potential yield from milking these cows outstripped demand, and/or because scarcity of labour inhibited heavy investment in encouraging let down without the calf. Conversely, the greater the importance attached to acquiring cow's milk for human consumption, the younger the age at which calves were weaned or slaughtered. Moreover, although many informants were well aware of calves being able to access the last fraction of milk that cows retained for this purpose, none cited this as a reason for delaying weaning or slaughter. On the contrary, some informants held that early weaning, by freeing cows from increasing harassment by growing calves, could significantly boost the availability of milk for human consumption. Finally, calves sometimes died or were slaughtered or removed at or very soon after birth and, in most such cases, herders could – if they invested sufficient effort – coax let down of milk.

Conclusions: rustic breeds, mortality profiles and milking

The experiences of pre-mechanised farmers with unimproved livestock offer invaluable insights to zooarchaeologists, but this study highlights two respects in which potential insights must be treated with circumspection. First, the Aubrac and Salers of central France and the regional rustic breeds of Greece alike underwent prolonged selection for particular (sometimes changing) production priorities, as well as for resilience, and their recent use reflects cultural demands and constraints as well as biological potential. Ethnozooarchaeologists must, therefore, deconstruct the ecological and historical context from which their information is drawn and should treat rustic breeds as prehistoric proxies with caution. Secondly, in central France and both north and south Greece, informants may offer sweeping generalisations ('nobody here milked cows') that are representative of central tendencies, but conceal vital variability in practices and outcomes that we ignore at our peril.

As for the disputed relationship between mortality patterns and milking, nineteenth century evidence from central France and more recent oral historical data from northern Greece indicate that slaughter of infant calves is entirely compatible with management for milk of rustic unimproved cows. More problematic is the equifinality of mortality data. In Greece, the milking of such cows accompanied slaughter of their offspring at various ages: up to 40–50 days old by Pontic refugees who prioritised milk over meat; from 2–3 months upwards on Kythira where meat was more important than milk but pasture was scarce; in the second year by farmers in Pieria who supplied urban butchers and had more abundant pasture and fodder; or in late adulthood when reared as replacement breeding cows and draught oxen. In other words, milking of unimproved cows is compatible with ‘milk’, ‘meat’ and ‘traction’ mortality (*sensu* Higham 1968; Legge 1981a) and ‘post-lactation kill-off’ (Balasse *et al.* 2000) – in effect with any mortality pattern that spares some adult cows. Mortality patterns thus cannot demonstrate the presence or absence of milking, for which organic residues in ceramics provide a more direct proxy. On the other hand, unlike ceramic residues, they may shed light on the *potential intensity* of dairying (Halstead 2014), and the testimony of recent cattle herders from central France and Greece unambiguously supports infant culling (or weaning) as leaving most potential for human use of milk. Furthermore, heavy culling of infant calves (or lambs or kids), which for reasons of seasonal ecology is unlikely to reflect lack of pasture, represents a dramatic sacrifice of potential carcass weight in subsequent months, favouring the existence of a competing priority, such as production of calf skins, tender veal, or milk. Post-lactation slaughter entails less sacrifice of potential carcass weight and, unless coupled with isotopic evidence for early weaning, is equally compatible with rearing large calves (constrained perhaps by scarcity of winter fodder), balancing meat and milk production (for example, if two teats were suckled and two milked), or even intensive dairying (if calves were mainly bucket fed). If mortality data alone are available, therefore, Tony was right – culling of infants provides the strongest hint in favour of intensive dairying.

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Age-at-death in traditional Cypriot sheep and goat husbandry: implications for zooarchaeology

Angelos Hadjikoumis

Prologue

This chapter is dedicated to Tony Legge, who worked in Cyprus and was an advocate of zooarchaeologists gaining a better understanding of animal husbandry and farming practices in the present. He has left an indelible mark in the field through the high quality of his work and the large volume of archaeological knowledge that he produced. Arguably his most valuable contribution was his ability to expose cherished but unjustified assumptions and flaws in methodology. Our discipline needs more of his spirit to avoid mechanical application of methods and uncritical reproduction of knowledge.

Introduction

Ethnography is frequently employed in archaeological interpretations. Naturally, there is a chasm between the ethnographic and archaeological records in terms of resolution and degree of integration between different categories of data. This invites criticism on the use of ethnographic analogy in archaeology. Such criticism usually focusses on assessing the degree of relevance of the ethnographic to the archaeological data on the basis of geography, climate, vegetation, cultural and socioeconomic traits, and so on. Following this logic, the more diverse and robust the ethnographic record, the more fruitful will it be in producing reliable archaeological interpretations. The potential of ethnography can be improved through more research with archaeological application in mind. This ethnozooarchaeological (*sensu* Albarella 2011, 2) study focuses on age-at-death of sheep and goats in traditional and modern husbandry practices in Cyprus and contributes to the enrichment of the interpretative models available to zooarchaeologists. Ethnography may be likened to a colour palette used by archaeologists to paint pictures of the past (i.e. to interpret data). The larger and more diverse it is, the more potential it has to enable archaeologists to paint pictures that resemble a long-gone reality.

Considerable ethnographic research has been carried out in Cyprus, mostly focusing on recent traditional society. The term ‘recent’ tacitly includes the end of the nineteenth and most of the twentieth centuries, roughly up to the end of the 1970s. Human–animal interactions are addressed in

several ethnographic studies as an important component of recent Cypriot society. Perhaps the most animal-focused study is that of Xioutas (2001), which presents a wealth of ethnographic information on all wild and domestic animals with which Cypriots interacted at least during the last century. Despite a linguistic and folkloric focus, Xioutas' work offers insights to pastoral life. The proverbs and folklore presented reveal traditional practices in areas such as seasonality, diet, animal products, practicalities of husbandry and the integration of different components of rural life. Christodoulou's (1959) thorough geographical study produced a wealth of quantitative and qualitative information on land use in Cyprus for the late nineteenth and first half of the twentieth centuries, including sections devoted to animal husbandry and to other topics (e.g. geology, vegetation, water resources, land tenure, crops, etc.) relevant to zooarchaeology or its integration with environmental data. More recently, Rizopoulou-Egoumenidou (2008; 2012) studied several aspects of traditional pastoral life in Cyprus such as its representation in art, herders' clothing and gear, pastoral proverbs, infrastructure, mating, diet, products and consumption. In addition to such studies on different aspects of the human–animal relation in recent years, British colonial (1878–1959) reports (e.g. Bevan 1919; Surridge 1930; Jones *et al.* 1958) and travellers' accounts (Harris 2007, 325–442 for a thorough review) often include information useful to the ethnozoarchaeologist.

Nonetheless, ethnozoarchaeological studies in Cyprus are non-existent with the exception of a small study by Tony Legge. While at Agios Epiktitos-Vrysi in 1972, he carried out a small-scale study of the area's farming economy through observations and discussions with farmers (Legge 1982, 14–20). He was planning to expand data collection in subsequent years but the Turkish invasion of 1974 permanently halted both the excavation and his ethnographic work. Since then, no major ethnozoarchaeological study has been published concerning Cyprus. Most ethnographic studies on sheep/goat husbandry have been carried out in continental (e.g. Payne 1973; Digard 1981; Chang 1994; Halstead 1998) rather than insular Mediterranean regions. This dearth of research in insular contexts inevitably results in the use of interpretative frameworks constructed in less relevant environmental conditions. Such use has been fruitful but leaves considerable scope for improvement in terms of relevance, resolution, and integration with other lines of evidence.

This chapter focuses on age-at-death in traditional sheep/goat husbandry in Cyprus, a topic central to Tony Legge's research interests. The chapter aims to increase the diversity and volume of recent age-at-death data, including that related to differences of strategy between individual herders, available to zooarchaeologists for the interpretation of archaeological data.

Methods

Data were collected by the author from April to September 2013 in Cyprus through semi-structured interviews with 23 herders of sheep, goats or both. Care was taken to ensure that interviews were perceived as casual by avoiding a rigid 'question-reply' format in which interviewees tend to provide shorter or idealised answers because they feel that they are expected to perform well. During interviews, specific themes were raised but conversation was allowed to expand in unforeseen directions. Beyond basic information about the herder, the themes addressed in the interviews were: 1) landscape and environmental setting, 2) general characteristics of herd, 3) age and sex composition of herd, 4) mobility, 5) diet, 6) practical aspects of husbandry and 7) consumption of animal products. These themes were selected for their relevance to zooarchaeological issues. This chapter focusses mainly on age-at-death, but other classes of data are inevitably mentioned, where necessary, to provide some context and thus make discussion more meaningful.

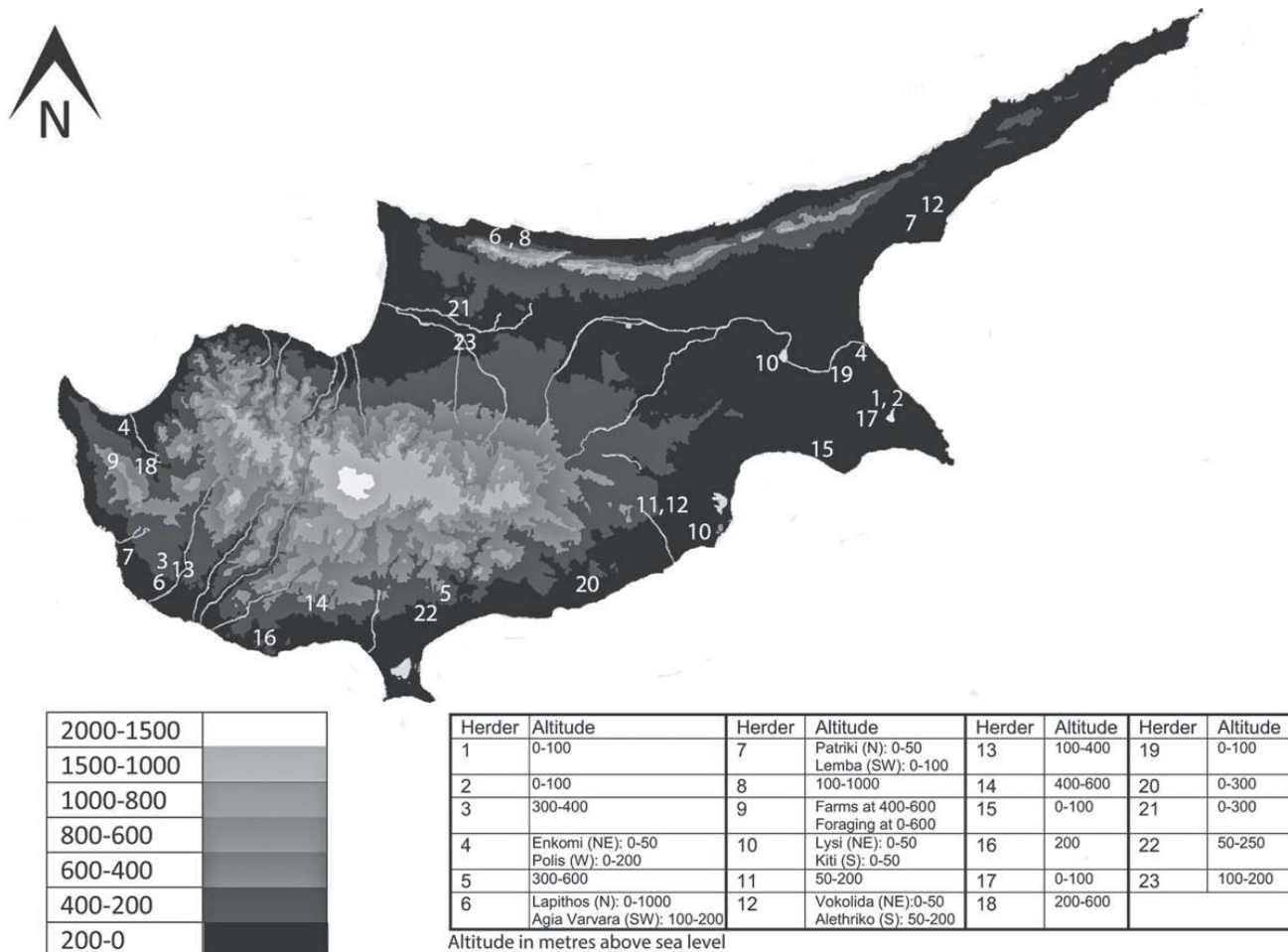


Fig. 15.1. Map of Cyprus showing the location and altitude of the area(s) in which interviewed herders managed sheep/goat. Key: numbers 1–23 link the map to the additional information provided for each herder in Table 15.1; for herders displaced in 1974, pre- and post-1974 locations are marked on the map by the same number.

Geographical coverage

Interviews covered all of Cyprus except high altitude areas (>800 m asl) of the Troodos range at the centre of the island (Fig. 15.1). The reasons for this geographic void are legal, in the case of goats, and mainly environmental, in the case of sheep. The absence of goat herds from high altitude areas is relatively recent (Given 2000) and attributable to a 1913 colonial law excluding them from government forests and many other areas or villages (e.g. Orr 1918, 141), roughly corresponding to land above the 800 m contour (Christodoulou 1959, 190, map 4). Tethered goats were allowed in areas of goat exclusion and generally ubiquitous (Christodoulou 1959, 191, map 5), but were not a target of this study. The absence of sheep at high altitude was attributed by interviewees to this animal's inability to thrive in steep mountainous terrain and tree/shrub-dominated vegetation (Christodoulou 1959, 189, map 3). Sheep husbandry in Cyprus during the last century was paired with dry farming, mainly of cereals and carob or olive trees in gentle hilly areas, the coast and the central plain (e.g. Bevan 1919, 2).

Table 15.1. List of interviewed sheep/goat herders and their basic information

Herder	Village-district	Sex	Age (yrs)	Active	Experience (yrs)	Family tradition
1	Deryneia-Ammochostos	Male	84	No	62	Yes. Father and grandfather
2	Deryneia-Ammochostos	Male	71	No	37	Yes. His father
3	Armou-Paphos	Male	95	No	44	No
4	Pre-'74: Enkomi-Ammochostos 1974–2013: Polis-Paphos	Male	80	Yes	65–70	Yes. At least back to great-grandfather
5	Fasoula-Lemesos	Male	78	No	48	Little. Parents had 1-3 goats
6	Pre-'74: Lapithos-Keryneia Post-'74: Agia Varvara, Paphos	Male	76	No	50–60	Yes. Since 1910.
7	Pre-'74: Patriki-Ammochostos Post-'74: Lemba-Paphos	Male	49	Yes (hobby)	40	Yes. At least back to great-grandfather
8	Lapithos-Keryneia	Male	60	Yes	45–50	Yes. At least back to grandfather
9	Ineia-Paphos (also some information on Peyeia-Paphos)	Male	64	Yes	48	Yes. At least back to great-grandfather
10	Pre-'74: Lysi-Ammochostos Post-'74: Kiti-Larnaca	Male	68–72	Yes	55	Yes. Father
11	Alethriko-Larnaca	Male	75–80	No	20–25	No
12	Pre-'74: Vokolida-Ammochostos Post-'74: Alethriko-Larnaca	Male	50–52	Yes	At least 30	Yes. At least back to grandfather
13	Nata-Paphos	Male	75	Yes	At least 60	Yes. Father and grandfather
14	Pachna-Lemesos	Male	73	Yes	50	Yes. At least back to grandfather
15	Xylofagou-Larnaca	Male	78	No	40	Yes. At least back to grandfather
16	Pissouri-Lemesos	Male	51	Yes	31	Yes. Father and grandfather
17	Deryneia-Ammochostos	Male	85	No	60	Yes. Father
18	Simou-Paphos	Male	63	Yes	40	Yes. Parents
19	Acheritou-Ammochostos	Male	61	Yes	50–55	Yes. At least back to grandfather
20	Maroni-Larnaca	Male	51	Yes	40–45	Yes. At least back to grandfather
21	Philia-Lefkosia	Female	67	No	19	Yes. Father
22	Agia Fyla-Lemesos	Male	67	No	50	Yes. Back to great-grandfather
23	Akaki-Lefkosia	Male	60	Yes	47	Yes. Father

The herders

Some of the interviewees became refugees in the 1974 war and so supplied information on both their pre-1974 and post-1974 experiences. The level of detail provided by each herder for each area was rarely balanced but priority was given to pre-1974 information as less affected by modern developments. Basic information on the 23 herders is presented in Table 15.1. Herding free-range (as opposed to stalled or tethered) animals was traditionally a man's profession in Cyprus and the only woman interviewed was herding outdoors with her brother and that only until she was engaged. More than half of the interviewees were above 70 and all except four above 60 years old. In addition, all except two had more than 30 years of experience as well as a long family tradition in herding. It was clear that family tradition and personal experience are sources of pride for herders. Many added that 'it is a difficult profession but once you've loved it during childhood you cannot change'. This shows that a certain way of life, common experiences and interests forge 'a herder's identity' that transcends local boundaries.

Breeds

The sheep/goat breeds owned by the herders are briefly described below. It should be noted that most animals are in reality crosses since breed replacement involves the introduction of male animals and not the substitution of entire herds. This is not intended to be a full account of the history of sheep/goat breeds in the twentieth century but a brief summary of the breeds exploited by the interviewees.

Sheep

1) *Cypriot*: The traditional fat-tailed breed of sheep, also common all over the Near/Middle East, Turkey and further afield. Based on the interviews this breed goes back to the mid-nineteenth century AD in Cyprus, but was present in the Middle East since at least the late fourth millennium BC (e.g. Ryder 1983, 90) and so was probably introduced to the island during late prehistory. This breed nowadays is almost extinct, at least commercially. Its main characteristics are low productivity in milk and lambs (at least in extensive systems without much additional feed) but high adaptability to local climate and environment.

2) *Chios*: The first breed extensively to replace the Cypriot. Of similar body size to the Cypriot, its principal differences are a higher lambing rate (two or more, whereas the Cypriot very rarely produced two), production of more milk (albeit usually of lower fat content), easier mating due to absence of a fat-tail, and earlier sexual maturity (although many herders attributed this to improved feeding). On the other hand, like all introduced breeds, it was inferior to the Cypriot in terms of climatic adaptation and vulnerability to disease.

3) *'Israeli'*: referring to the Awassi breed, as the name suggests probably imported to Cyprus from Israel after it had been improved. Its advantages were similar to those of the Chios breed, but it was of larger body size and better adapted to Cypriot conditions.

4) *'German'*: refers to the East Friesian breed, the latest arrival of the breeds owned by interviewees. It is even more productive in all aspects except body size (which is similar to the Cypriot, Chios and unimproved Awassi), but is more labour intensive and not well-adapted to Cypriot climate as it needs considerable help during lambing, cannot forage outdoors in hot weather and requires high-quality feed.

Goat

1) *Cypriot*: a diverse breed of variable size and coat colour, characteristics that define several 'tribes' within Cyprus. Its main common characteristics are erect short ears and short hair, good adaptation to Cypriot climate and abrupt terrain, small litter size (usually 1–2 kids) and ability to thrive as feral.

2) *Damascus*: less well-adapted but produces more kids per litter and has larger body size than most 'tribes' of Cypriot goat, though not all (e.g. some areas of the Pentadactylos range in the north).

3) *Maltese*: early arrival in Cyprus to improve milk production but nowadays of restricted use, only mentioned by one herder.

4) *Saanen*: relatively recent arrival, of restricted use, owned only by one herder. Its main advantage is improved milk production but usually in intensive systems.

5) *Alpine*: same characteristics as Saanen.

The information provided by herders on the appearance and substitution of the different breeds is not deemed precise enough for more detailed presentation, but some chronological trends in breed replacement should be noted. Most interviewed herders of sheep began their careers in the 1950s and

1960s with the Cypriot breed, which is nowadays not used by any of them as a pure breed. Most herders started replacing the Cypriot breed through crosses in the late 1950s and 1960s with Chios and, slightly later, with Awassi sheep. The East Friesian breed gained importance in the 1980s and 1990s. Since the 1960s, the government's Agricultural Research Institute has supplied herders with improved animals from its experimental farms. Zootechnical research in Cyprus is currently targeting improved lamb and milk production, faster growth, early weaning techniques and, even more importantly, resistance to disease, especially scrapie. The same tendencies in breed improvements are observed in goats. Most herders started with Cypriot goats, but since the late 1960s and 1970s these have been crossed with or replaced by the Damascus breed. Other breeds like the Saanen and Alpine were rarely mentioned and their influence on the genetic make-up of goat populations in Cyprus is small. Unlike the Cypriot sheep, the Cypriot goat is still exploited as a pure breed by some herders, especially in areas with demanding terrain. The majority of goats nowadays, however, are pure Damascus or crosses of Damascus and Cypriot.

Table 15.2. Age-at-death data for lambs and kids

<i>Herder</i>	<i>Age-at-death of lambs</i>	<i>Age-at-death of kids</i>
1	Traditionally 2–2.5 months	–
2	For milk 45 days–2 months. For meat 5–6 months	For meat 5–6 months
3	Traditionally 2–3 months	2–3 months
4	Traditionally 40–60 days, some 6–8 months, nowadays 3 months	–
5	Traditionally 2–3 months, preferred 5 months	Traditionally 3–4 months
6	–	Traditionally 3–5 months
7	Traditionally 2–2.5 months, some 4 months	–
8	–	–
9	–	Traditionally 4 months, nowadays 4–6 months
10	100 days	5–6 months
11	Recently 3–4 months	–
12	Traditionally 3–5 months, nowadays 3–6 months	–
13	Traditionally 3 months	Nowadays 5 months
14	Traditionally 6–7 months, nowadays 4 months	Traditionally 6–7 months, nowadays 4 months
15	Traditionally younger than nowadays	–
16	Recently/nowadays well-fed 2.5 months	Recently/nowadays 3–4 months
17	Traditionally 2–3 months, recently 4–5 (even 6) months	–
18	Nowadays 3 months	Traditionally 8–9 months, nowadays 4–5 months
19	Traditionally 3–4 months	Traditionally 3–4 months
20	Traditionally 3.5–4 months	Traditionally 5–6 months
21	–	Traditionally 4 months, some 2 months
22	4 months	Around 5 months
23	Traditionally 3 months, some at 2 months	–

Key: 'traditionally' refers to pre-1974 practices, 'recently' to 1974–2000 and 'nowadays' to 2000–2013; absence of these terms indicates chronologically imprecise or generic information.

Results

Table 15.2 shows age-at-death data for lambs and kids provided by 19 and 14 herders respectively. Lambs were traditionally slaughtered at younger ages (2–3 months) than kids (3–5 months). The age-at-death overlap between lambs and kids is extensive but a trend for younger lambs is clear, also

supported by weaning ages (not presented here). Despite seasonal fluctuations in the composition of milk due to differences in nutrition, herders unanimously attributed this to the ewe's richer milk compared to that of the doe. Herder 21, an exception to the general pattern, explained that a few kids were traditionally slaughtered at 2 months if a doe had two or more kids and could not suckle all of them adequately. Rennet for cheese manufacture was also obtained from such kids slaughtered before weaning.

For lambs, there is a trend to older age-at-death in recent/modern compared to traditional practices (Table 15.2). Besides recent market forces favouring older/heavier lambs, many herders attributed this trend to their effort in the past to exploit more of the milk since they could not afford feeding to boost the duration of milk production. Herder 2 mentioned that lambs should be slaughtered around 2 months to optimise milk production, but at 5–6 months for meat production. Such specialised strategies were traditionally difficult to achieve due to the unpredictability of important inter-annual factors such as climate, availability of pasture and fodder, and demand for meat or dairy products.

Table 15.3. Age-at-death data for ewes and rams

Herder	Age-at-death of adult sheep	
	♀	♂
1	Traditionally/recently 5–6 years	Same
2	Traditionally 'until dead of old age'	N/A
3	Traditionally more than 5–6 years	Same
4	Traditionally 10+ years, recently/nowadays 5 years	Traditionally 'younger than ewe', recently/nowadays 1–2 years
5	Traditionally 5–7 years	Traditionally 'the older the better'
7	Traditionally, usually 12, up to 15 years	Traditionally 6–7 years or older
9	Traditionally 7 years	Traditionally 10–15 years
10	Traditionally/nowadays 8 years or earlier	Same
11	Recently, usually 4 years	Older
12	Nowadays (Chios/German) 5–6 years	Nowadays (Chios/German) 5–6 years or older
14	Traditionally 5–7, nowadays 6–10 years	Same
15	Traditionally 6 years	Same
16	Recently/nowadays 7–8 years	Same
17	Traditionally/recently 5–6 years	Traditionally/recently good ones 6–7 years
19	Traditionally 7–8 years, some older	Traditionally 8–10 years, some older
20	Traditionally 10 or 'as long as they bred', nowadays (mixed breed) 5–6 years	Traditionally same as ewe, nowadays (mixed breed) 3–4 years
22	Traditionally 8–10+ years, nowadays less than 8 years	If healthy, many years
23	Traditionally 6 years, nowadays younger	Traditionally 6–7 years, nowadays younger

Key: 'traditionally' refers to pre-1974 practices, 'recently' to 1974–2000 and 'nowadays' to 2000–2013; absence of these terms indicates chronologically imprecise or generic information.

In addition to the usual age-at-death range of 2–3 months (also noted by Legge 1982, 18), herder 4 provided two cultural reasons for slaughtering lambs at 6–8 months old. In some villages of the central plain (Mesaoria), many herders every year selected around ten male lambs to be fattened more intensively. Born between January and March, they were destined for slaughter at the Agios Anastasios fair in September. The same herder added that another reason to slaughter sheep older than 6 months was the demand for cooking fat (stored in its fat-tail) by Turkish-speaking Cypriots (Greek-speaking Cypriots raised pigs for this purpose).

To avoid repetition, animals failing selection (because they were injured, sick or barren) and so slaughtered before the end of a normal productive life, are omitted from the tables showing age-at-death results for adults (Tables 15.3 and 15.4). The age-at-death results for sheep are quite diverse with ample overlap between sexes (Table 15.3). Traditionally, healthy ewes were never slaughtered earlier than 5 years and usually older, with many reaching 10 or even 15 years (*cf.* Legge 1982, 18). Further examination of the data, coupled with oral testimonies of herders, suggests that the prime productive period for most ewes was traditionally between 3 and 7 years old. Rams were slaughtered at similar but slightly older ages, with almost all herders asserting that ‘the older the ram, the better his seed’. Herders 4 and 20 provided younger ages for rams than for ewes but without explanation. Ewes and rams exhibit a similar trend of change over time, with older age-at-death traditionally than nowadays. Herder 14 was an exception to this pattern, citing in justification improved conditions and nutrition nowadays.

The age-at-death for goats is also diverse (Table 15.4) but with more obvious patterns than sheep. Traditionally, female goats were slaughtered at no younger than 5 and in most cases more than 10 years of age, with some even reaching 16–20 years. Traditionally and nowadays, bucks exhibit almost no overlap with females, being slaughtered at 2–3 years or younger. All herders mentioned that young bucks produce larger kids than old ones. Many even attributed increased stillbirths or deformations to the decreased semen quality of bucks older than 3 years. The well-known saying ‘kid from a young buck and lamb from an old ram’ perfectly encapsulates their strategy. Herder 16 provided the additional reason that bucks older than 3 years become too heavy for mounting. Only feral bucks exploited by herder 8 reached 7 years or older, because he had little control over these animals. Herder 13 added that the rare occasions when bucks exceeded 2–3 years were because his family could not afford to keep or buy younger males. The effect of modernisation on age-at-death is similar to that observed for sheep, i.e. a trend towards younger age-at-death.

Table 15.4. Age-at-death data for does and bucks

<i>Herder</i>	<i>Age-at-death of adult goats</i>	
	♀	♂
2	Recently 4–5 years	N/A
3	Varied according to productivity (usually more than 5–6 years)	Same
6	Traditionally (small scale) around 12 years, recently (medium/large scale) 5–10 years	Traditionally/recently 2 years
8	Traditionally (feral) 15, even 20, nowadays 4–5 years <i>Not interviewee's case, generally in area</i> Traditionally (domestic) ‘until they could not walk anymore’	Traditionally (feral) 7+ years <i>Not interviewee, generally in area</i> Traditionally/nowadays (domestic) 2– years
9	Traditionally/nowadays 7 years	Traditionally/nowadays 3 years
13	Traditionally/nowadays average 8, range 5–12 years	Traditionally 2–5, nowadays 2– years
14	Nowadays 6–7 years	Nowadays 2–3 years
16	Recently/nowadays 7–8 years	Recently/nowadays 2–3 years
18	Traditionally/nowadays 7 years	Traditionally/nowadays 2–3 years
19	Traditionally 7–8 years, some older	Traditionally maximum 3 years
20	Traditionally usually 10+, nowadays 5–6 years	Traditionally 2–3, nowadays 2 years
21	Traditionally 7 years	Traditionally maximum 2 years
22	Usually 8–10 years (record 16 years)	Maximum 2 years

Key: ‘traditionally’ refers to pre-1974 practices, ‘recently’ to 1974–2000 and ‘nowadays’ to 2000–2013; absence of these terms indicates chronologically imprecise or generic information.

Discussion

To provide the necessary context for discussing these age-at-death results, the traditional sheep/goat husbandry system in Cyprus is briefly outlined here based on interviewees' accounts. Sheep/goat husbandry was of small-medium scale (usually 80–150 animals), extensive or semi-extensive usually within a 5–10 km radius from the village, although there is good evidence for seasonal movements of animals over longer distances (Given 2000). Under the extensive and semi-extensive system, most sheep/goat herders either produced their own dairy products or sold milk to regional dairies. Meat brought seasonally significant income, mostly through the sale of lambs/kids to butchers during the festive seasons of Christmas and Easter. Animals of 1–2 years and older were slaughtered only if they became unproductive (e.g. barren, injured, low milk yield) or to meet cultural demands such as financing a dowry or supplying a wedding feast or village/regional fair. Wool was a welcome, but secondary, source of income and prices declined from the 1960s until exports collapsed in the early 1990s. Sheep wool, fleeces and goat leather were used in the manufacture of clothing, boots and bedding. Manure was mentioned frequently by both sheep and goat herders as either a direct source of income through sale/exchange or a valuable boost to the productivity of the herder's fields, usually sown for animal consumption. Overall, this system was in most lowland areas adapted to articulate with extensive dry farming of cereals, also practised by many herders to improve the availability and quality of feed for their animals.

The main aim of this study is to enhance the potential for interpreting sheep/goat zooarchaeological age-at-death data. The results provide new interpretative options and improve existing ones. It is commonplace in zooarchaeology that precise age-at-death is blurred by many factors (e.g. Marom and Bar-Oz 2009, 1186), several of which are variable in time and space (*cf.* Cribb 1987). Nevertheless, herders expressed a strong preference towards old rams and young bucks for reproduction and clearly, if ancient herders consistently applied a similar strategy, this would affect sheep/goat age-at-death profiles. Thus, breeding males would contribute to mortality between one and three years old in assemblages dominated by goats, but to mortality in the oldest age categories if sheep were predominant, although this difference might be difficult to detect given the usually low proportion of males and the common zooarchaeological practice of pooling sheep with goat and males with females.

The data from Cyprus also contribute to refined interpretation of the age-at-death of lambs and kids. Herders slaughter lambs at a consistently younger age than kids and the main reason is the faster growth rate of lambs fuelled by the richer milk of ewes (Hadjipanayiotou 1995; Hadjipanayiotou and Koumas 1994). Consequently, proportions of sheep to goat affect the pattern of mortality at 0–6 months. If ancient herders followed the practice of their recent Cypriot counterparts, assemblages with more goats would produce mortality peaks at slightly older ages than assemblages with more sheep. Many Cypriot herders also stressed that lambs/kids kept stalled, while their mothers are out foraging, grow faster because they conserve energy. With the same logic, faunal assemblages representing a more mobile system may exhibit a shift towards older age-at-death amongst lambs/kids. A further consideration is that goats produce more offspring (e.g. Payne 1973, 301), which affects the composition of the 0–6 months cohort by 'drowning' the contribution of lambs.

Rapid modernisation in Cyprus roughly from the 1970s onwards has brought significant changes in many aspects of husbandry practices (Papachristoforou and Markou 2006), among which the differential effect on age-at-death in young and adult sheep/goats is notable. Age-at-death for lambs/kids has increased while that for breeding adults has decreased. Older age-at-death for lambs/kids was explicitly attributed to modern market forces and younger age-at-death for adults to

recently acquired knowledge of optimisation strategies and to the more intensive nature and larger scale of modern husbandry. Nevertheless, most herders expressed the view that local breeds of sheep/goat, despite being inferior to introduced ones in terms of productivity, are better-adapted to thrive in conditions specific to Cyprus, less labour-intensive and more resistant to disease (*cf.* Papachristoforou *et al.* 2013). This observation is archaeologically relevant in contexts with evidence for introduction of breeds, especially if accompanied by economic/technological developments and an increase in the scale of husbandry. In such contexts, increased losses of lambs/kids and younger age-at-death for adults could be attributed to disruption of a previously stable husbandry regime and delayed adaptation to new conditions (ongoing for the past several decades in Cyprus).

Beyond the overall age-at-death patterns discussed above, herders revealed finer-tuned decisions likely to affect age-at-death. For example, herder 21 mentioned the traditional strategy of slaughtering one or more kids of a specific doe to allow more milk for the remaining kid and/or for human consumption. If also in the past goats produced more twins than did sheep, then a strategy of slaughtering one kid may have been exercised for the same reasons and to satisfy the need to obtain rennet for dairy products. Herder 2, who also was a butcher, mentioned two strategies for lambs, one focussing on milk with culling at 1.5–2 months (*cf.* Halstead 1998, 8 on sedentary sheep herders in lowland northern Greece) or even 3 weeks in towns where demand for milk was higher (Rizopoulou-Egoumenidou 2008) and another focusing on meat with culling at 5–6 months. Culling at 1.5–2 months or earlier leaves little doubt as to the strategy represented, i.e. milk exploitation according to Payne (1973). However, herder 2 added that intensively fattened lambs (or kids), even if kept alive longer, would not gain much more than 2–3 kg per month for the next few months. By 5–6 months most reached adult weights and were heavier than breeding ewes. Given slower growth rates in the distant past, the equivalents of these intensively fattened 5–6 month old lambs/kids would probably fall in the 6–12 month age interval, in accordance with the ‘meat A’ mortality model (Helmer and Vigne 2004; Helmer *et al.* 2007, 48, table 1). Accordingly, the traditional Cypriot age-at-death for lambs at 2–3 and kids at 3–5 months can be characterised as a mixed meat and milk strategy with an emphasis on milk, at least in most cases. Another important point stemming from this is related to the style of husbandry. Under intensive/stationary husbandry (e.g. the fattened lambs/kids of herder 2) animals slaughtered for meat are expected to be slaughtered younger than under an extensive/mobile system. In fact, the traditional Cypriot system best matched a mixed strategy resembling Helmer and Vigne’s meat model A in some respects and Payne’s milk model in others. This point will be further developed elsewhere in the future.

Lastly, herder 8 provided information on a peculiar style of goat exploitation that may have archaeological relevance. He was exploiting feral goats, previously released by his father due to the colonial law, through systematic harvesting of kids and the occasional hunting of adult goats. Such a practice in the past would have distorted age structure due to a disproportionately high input of kids of varying age. In such a situation, confusion between milk and meat models is likely since the presence of kids would imply some degree of milking which did not take place at all. His strategy of capturing or shooting kids and old animals maintained the sustainability of the system. Within the adult category, most goats were killed around 15 years because they started suffering mobility problems and would be captured by thieves or dogs. Before shooting, he aimed at the back of the skull so that animals would either die instantly or survive to be shot another day. He also admitted that in this way he could erase proof of his illegal action by removing the animal’s head before selling it to butchers or other households.

Conclusions

This ethnozoarchaeological study of age-at-death has opened a window onto the strategies employed by Cypriot sheep/goat herders, which in turn open up a range of interpretative options to zooarchaeologists. First, it has improved the potential of evaluating the age-at-death in the youngest age intervals (0–6 months) based on the proportions of sheep and goat. Age-at-death of the youngest cohorts should shift upwards by a month or two, if goats are in the majority, and downwards, with a majority of sheep. A complicating factor is the goat's multiparity, which inflates the proportions of kids to lambs but may also promote the culling of some kids before weaning to relieve breeding goats and/or increase milk production. Secondly, the striking difference in age-at-death between rams (10+ years) and bucks (1–3 years) should be borne in mind in the interpretation of ancient age profiles, even if male animals usually have a minimal effect due to their low numbers. Thirdly, when a traditional system is disrupted by the introduction of new breeds and technological improvements, a change towards overall younger age-at-death for adult animals and higher losses to disease and climatic adversity is likely. Fourthly, the style of husbandry affects the growth rates of animals and thus possibly the age at which an animal acquires the desired weight for slaughter or reaches the end of its prime productive age. Broadly speaking, sheep and goats under intensive/stationary systems achieve production thresholds at an earlier age than under extensive/mobile regimes. This should be taken into account, where feasible, before mechanically applying published models of sheep/goat exploitation to archaeological age profiles. Fifthly, the exploitation of feral populations in parallel to domestic introduces significant biases depending on the modes and aims of each system.

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A calf's eye view of milk production: Tony Legge's contribution to dairy husbandry studies

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Introduction

This article is a discussion of Tony Legge's contribution to dairy husbandry (Legge 1981a; 1981b; 1992) and will focus on the identification and interpretation of calf slaughter. Providing accurate chronological ages is important for studying husbandry using ethnographic and modern references. Gillis *et al.* (2013a) have demonstrated that Legge's 1992 dental age determination scheme is more accurate than methods based on nineteenth century veterinary studies. Since Legge's publications there have been a number of further studies that have demonstrated that dairying was practised from the Neolithic onwards. These potentially indicate that a number of calf slaughter strategies were practised for milk exploitation, depending on cultural demands.

The Grimes Graves excavations during the 1970s produced two rich assemblages of archaeozoological material from Bronze Age midden deposits. This contained a large concentration of excellently preserved juvenile cattle remains, primarily consisting of mandibles. Legge conducted an analysis of the cattle mortality together with a post-cranial analysis of the ratio of males to females. From these, he proposed that the cattle were managed for milk production. He was one of the first researchers to propose that cattle dairy husbandry was practiced by early food producing societies, basing the proposal that milk production was practised at Grimes Graves on the slaughter of young calves. The removal of offspring early in the lactation period is similar to the milk model proposed by Payne (1973) for small stock. Legge's interpretation was criticised at the time by Clutton-Brock (1981), and with the publication of 'secondary products revolution' by Sherratt's (1981; 1983) the role of dairying in early prehistory was marginalised. However in the last two decades, the role of dairying in Neolithic and later prehistoric societies has been confirmed with the increasing evidence from ceramic lipid residues, archaeozoological mortality and stable isotopic analysis (Copley *et al.* 2003; Balasse *et al.* 1997; Balasse and Tresset 2002; Helmer *et al.* 2005; 2007; Evershed *et al.* 2008; Vigne and Helmer 2007).

LeCHE or *Lactase persistence and the Cultural History of Europe* was a Marie Curie initial training network (FP7-ITN-215362-2). This 3 year project was a collaboration of 13 different research strands to investigate the development of dairying practices during the Neolithic and the relationship with lactase persistence in humans. Team LeCHE invited Legge to ICAZ in Paris 2010 to be our

keynote speaker during the dairy session. He subsequently became an enthusiastic and encouraging friend of the project. My role within the LeCHE project, under the supervision of Jean-Denis Vigne (MNHN, Paris), was to investigate the beginnings of dairy husbandry and identify the development of specialised dairy husbandry practices during the European Neolithic through the analysis of archaeozoological remains, mainly dental and unfused post-cranial bones of cattle.

In this paper I will return to Legge's seminal research into prehistoric dairy husbandries by examining the role of the calf in the light of new ethnographic and archaeozoological research. The removal of the calf was key part of the dairy interpretation proposed by Legge for the Grimes Graves material. We will begin from the point of determining the age-at-death.

Dental age determination

For the analysis of the second assemblage from Grimes Graves, Legge (1992) identified two main issues with the Higham (1967) age scheme used in his 1981 analysis: 1) the tooth eruption stages were subjective; 2) the absolute ages assigned to each age stage were based on veterinary studies which describe eruption through the gum. Consequently, he proposed a new dental scheme for age determination of cattle based on a study of juvenile mandibles from reference collections at Cambridge and the Department of Extra-Mural Studies, University of London. The scheme uses the early tooth development and dental eruption codes from Ewbank *et al.* (1964), and the illustrations of tooth wear by Grant (1982). The use of these eruption and wear stages reduced the subjectivity of the definitions of Higham. These stages can provide a relative proxy for the timing of animal mortality. However, they cannot be compared with ethnographic references of animal slaughter management due to the lack of chronological ages.

The use of suggested absolute ages for stages of dental eruption, development and wear is problematic due to the problems associated with the 19th century veterinary studies. The subject is extensively reviewed by Payne (1984), Legge (1992) and Jones and Sadler (2012a; 2012b). The main problems with the nineteenth century veterinary references are: 1) in most cases the dental schemes derive from previous studies, not referenced, which have been shown to be inaccurate (Payne 1984); 2) the appreciation of certain tooth eruption differs between authors (Payne 1984); 3) the original primary sources studies were of live animals and consequently, the eruption timings are based on the appearance of the tooth in the oral cavity and not through the bone. Legge's suggested ages are based on the study of calf mandibles obtained by Dale Serjeantson in 1982 from the University of Liverpool Veterinary School (Serjeantson 2013, 48) and radiographic studies of Brown *et al.* (1960) and Diesem *et al.* (1971). Consequently, Legge's scheme was the first archaeozoological-friendly age reference scheme with a suggested chronological age for crown development stages (Fig. 16.1).

Breed development may affect dental eruption timings, and this has been the main criticism of using modern cattle to age-at-death for archaeozoological material (Hambleton 1999). Eruption times given by Girard (1834) and Leyh (1850) for late maturing animals have often been taken to be representative of unimproved breeds, i.e. similar to prehistoric ones (Silver 1963). The inaccuracies of the nineteenth century references cast doubt on whether there is a difference in eruption timings between modern and prehistoric breeds. Empirical studies conducted in the nineteenth century can be used to study the effect of breed development on eruption. Simonds (1854) noted no differences in terms of molar eruption between breeds. The same conclusion had been reached by Cornevin and Lesbre (1894) who compared common breeds (shorthorn Dutch) with specialised French meat/traction breeds. Studies of modern Friesian and Aberdeen Angus breeds have also noted no significant differences between breed types (Brown *et al.* 1960; Andrews and Wedderburn 1977; Graham and

Price 1982). Comparative reference studies of ‘traditional’ breeds and modern single purpose animals may provide answers but it may never be completely resolved for archaeozoological analysis.

Recently, Gillis *et al.* (2013a) demonstrated a close correspondence between Legge’s 1992 dental scheme and ages estimated from post-cranial measurements. Linear age prediction models were produced for diaphyseal and epiphyseal elements from post-cranial long bones, astragalus and calcaneus from 26 calf reference skeletons with known ages (<12 months). The models were tested using an assemblage of nine calves from a causeway site at Bourginon-lès-Morey (‘Néolithique Moyen Bourguignon’; 4200–3600 cal BC). Arbogast and Piningre (2007) had demonstrated that all the individuals were close in age (around 6 months). The test compared the dental age determination scheme from Higham and Legge (1992). The results demonstrated that the Legge scheme correlated (within a 95% CI) with the age prediction models. We concluded that this was because Legge’s scheme was based on the dental eruption through the bone, as illustrated by Simonds. Therefore, the Legge scheme is more appropriate for archaeozoological material. If it is combined with the method of Gillis *et al.* (2013a) for unfused bones, the resolution of age determination improves.

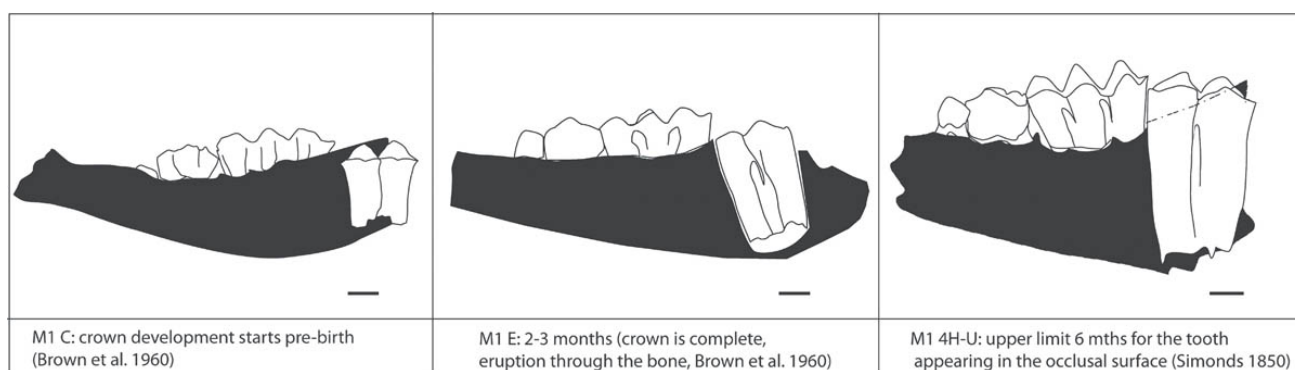


Fig. 16.1. M1 eruption stages. M1 C: crown development starts pre-birth (Brown *et al.* 1960); M1 E: 2-3 months, crown is complete, eruption through the bone (Brown *et al.* 1960); M1 4H-U: upper limit 6 months for the tooth appearing in the occlusal surface (Simonds 1854). C, E and 4H-U, after Ewbank *et al.* (1964); Jones and Sadler (2012b). Illustration: RG based on material from Popina Bordusani, Romania; scale 1 cm.

An ethnographic and historical framework

Legge’s dairy interpretation, which was based on the early removal of the calf, was strongly criticised by Clutton-Brock (1981; 1989). This is based on the fact non-specialised cattle are sensitive to the loss of the calf. The ejection of milk from the lumen to the teat cisterns is stimulated by the hormone oxytocin, which is produced by stimulation of sensory and tactile stimulus of the young or by artificial means (Labussière 1999). In modern dairy breeds such as Friesians, the need for stimulation has been reduced through artificial selection. African breeds are often cited as a reference for early domesticated cattle breeds (Clutton-Brock 1981; 1989; Entwistle and Grant 1989; Balasse 2003) because they have not undergone intensive breed selection compared to cattle from Europe (Clutton-Brock 1989). Legge (1992) criticised the use of the African breeds as reference for European animals due to the contrast in environmental conditions between Europe and Africa, which can have a significant effect on milk production. Another important point is that several of African breeds have both zebu and taurine bloodlines (Troy *et al.* 1999). There are physiological differences in lactation length and let-down rate between taurine and zebu cattle (Alvarez *et al.* 1980; Madalena 1988; Junqueira *et al.* 2005).

Jewell (1981) in his summing-up of the stimulating symposium published as *Farming Practice in British Prehistory*, called for more ethnographic examples to aid interpretations. There are issues with finding relevant ethnographic examples due to the industrialisation of cattle husbandry. However the comparison between modern systems and historical written accounts of dairy husbandry can provide relevant common points between the former and the latter (Legge 1981a). Table 16.1 presents a summary of weaning, calf slaughter and female productive life span for modern intensive dairy and beef systems from the UK; large to medium scale dairy and meat production from France and Italy; medium to small scale using dual purpose animals from Turkey; and the semi-wild breed Beitzu. Feral cattle are also provided here as an example of the ‘natural’ system: observations of these animals indicate that the calf may stay with its mother for up to 15 months. At present in large-scale dairy operations, animals are removed within the first 48 hours, and then raised on substitute milk supply. Male calves are sold on to veal or beef enterprises or are culled, whereas female calves are kept for herd reproduction (Bazeley and Hayton 2007). ‘Suckler’ herds are a common practise of beef rearing operations, and often bull calves from dairy breeds are sold to these herds to be reared for meat and weaned around nine months.

Table 16.1. Different cattle management systems detailing breed type, origin, birth season, suckling length, weaning time, slaughter age, adult production life from European and Turkish examples

<i>Breed</i>	<i>Breed type</i>	<i>Origin</i>	<i>Birth season</i>	<i>Weaned (months)</i>	<i>Slaughter (months)</i>	<i>Female productive life span (years)</i>	<i>Reference</i>
Semi-wild Beitzu	Wild	Basque Country, Spain	March	15 (become independent)	NA	14–15	Gomez <i>et al.</i> 1997
Grey Steppe	Dual	Turkey	Late winter–Spring	7–8 (suckling for 4–5 months)	Slaughter 2–2.5 years	10	Soysal and H�k 2006
Montb�liarde/ others alpine breeds	Dairy	Alpine, France	Autumn	2–3	Males sold: 2–3 weeks	8–10 (intensive 6–7)	Meure <i>et al.</i> 2006
Podolian/ Modiana	Beef	Italy	Feb–April	9	10–and 18–month aged carcasses	NA	Napolitano <i>et al.</i> 2005
Friesian/ Shorthorn cattle	Dairy	UK	All year	2–3 (removed up to 4 days after birth)	Males sold to suckler herds	6–7	Bazeley and Hayton 2007
Aberdeen Angus; Friesian	Beef	UK	Spring	6–10	Veal: 4–6 Bull beef: 14 Heifers: 23–24	15	Bazeley and Hayton 2007

NA=not available.

There is a difference between suckling and weaning length in the example from Turkey. Here calves have unrestricted access to their mothers for 4–5 months, and then are restricted until weaned at 7–8 months. A consequence is that milk production is shared between humans and calves. This is common practice for dual/multi-purpose animals and is evident in other breeds such as Salers (France; Bonal *et al.* 1985) and Modiana (Italy; Rosati 2000). Meat is also produced from these herds and allowing the calf to suckle ensures faster-maturing and heavier animals for slaughter. The dual-purpose example given here may have been commonly practised during prehistory. Many milking scenes ranging from rock art to decorative temple freezes from prehistoric and proto-historic contexts show the milking of a cow with her offspring tethered to her leg, or close by (Fig. 16.2a; Amoroso and Jewell

1963; Balasse *et al.* 2000; Le Quellec 2011). The ‘post-lactation’ mortality model proposed by Peske (1994; Fig. 16.2a) reflects this husbandry system, which relies on the calf for milk production. In this model, calves, particularly excess males, would be slaughtered after lactation, which would produce a peak in a mortality profile at between 6 and 12 months. This type of slaughter has been identified at Bercy (Chasséen; fourth millennium BC; Tresset 1996), in several Middle Neolithic sites from France (Vigne and Helmer 2007, Bréhard *et al.* 2010) and at Borduşani-Popină, Romania (Gumelnița, late fifth millennium BC; Bréhard and Bălăşescu 2012). Stable isotopic studies, using $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$, have demonstrated that animals that were weaned were within the post-lactation slaughter peak. Therefore this suggests that stockherders slaughtered calves at the end of the lactation period, and may have used them to maintain milk production. Consequently, these biochemical proxies have been used to demonstrate that cows were managed for milk production (Balasse and Tresset 2002; Gillis *et al.* 2013b).

As Table 16.1 shows, the extent of calf slaughter consequently depends on the scale of the operation, external markets, and the price and availability of fodder. This was also a concern during the sixteenth century particularly balancing the calf’s need for milk with those of the owner, and with the cost of raising the calf (Legge 1992). Irish medieval examples describe the removal of the calves at birth to conserve milk for human use, and a historical document of 1872 stipulated that bull-calves should be removed and only heifers raised (Lucas 1989, 225–226). If the cow is affected by the loss of her calf, there are artificial stimulation means of let-down: cow-blowing and dummy calves. Cow-blowing is when air is blown into the rectum or vagina to induce milk let down (Amoroso and Jewell 1963; Lucas 1989; Balasse 2003). Hollow sticks or shells can be used to blow air into the cow (Le Quellec 2011). Historical sources report that during the eighteenth century the English parliament was shocked by reports of Irish stockherders practising cow-blowing to stimulate milk production (Lucas 1989). The second method, calf dummies, is where the skin of the dead calf is removed and stuffed or placed over a mount to induce milk let down (Amoroso and Jewell 1963; Balasse 2003). This is a common method for encouraging adoption of orphaned lambs (Balasse 2003; Tani 2005). The first literary account of the use of a dummy calf in Ireland appears in the sixteenth century (Lucas 1989, 52). There are also a number of stories featuring Irish saints from the medieval period where the saint induces another animal, often a wolf, to be the calf replacement if calf has been killed or died (Lucas 1989).

Finally, modern cattle dairy systems, particularly those practising organically to ensure good welfare practices, employ nurse cows to free up lactating females for milk production and to rear stronger calves. Sixteenth century treatises on husbandry recommend the employment of a nurse cow for weaning calves from their mothers and to ensure more milk production for human consumption (Fussell 1966). Adoption of calves was also discussed by the Roman author Columella (vi, xxiv). He describes the small *Altinian* cattle as having great quantities of milk, which allowed for easy adoption of calves. For sheep and goats, offspring can be shared between lactating females to ensure their survival (Tani 2005). This increases milk production as the suckling is shared. An adopted calf could be suckled on one cow but also be used to stimulate let down of another. In this scenario, a selective cull is practised to remove the males and/or weak looking calves at a young age, while those remaining are shared between females (Fig. 16.2b). This may be thought to be unrealistic in prehistory, given the sensitivity of cattle to the removal of the calf during lactation and there are no ethnographic examples of this type of adoption. However Neolithic populations practised many specialised innovative technologies such as flint knapping (Vigne and Helmer 2007) so we should remain open to the possibility of this type of dairy husbandry where one calf was used to stimulate several cows. Stable isotopic analysis coupled with accurate age determination could compare the suckling/rumination

status of animals culled to those that remained alive to be slaughtered later.

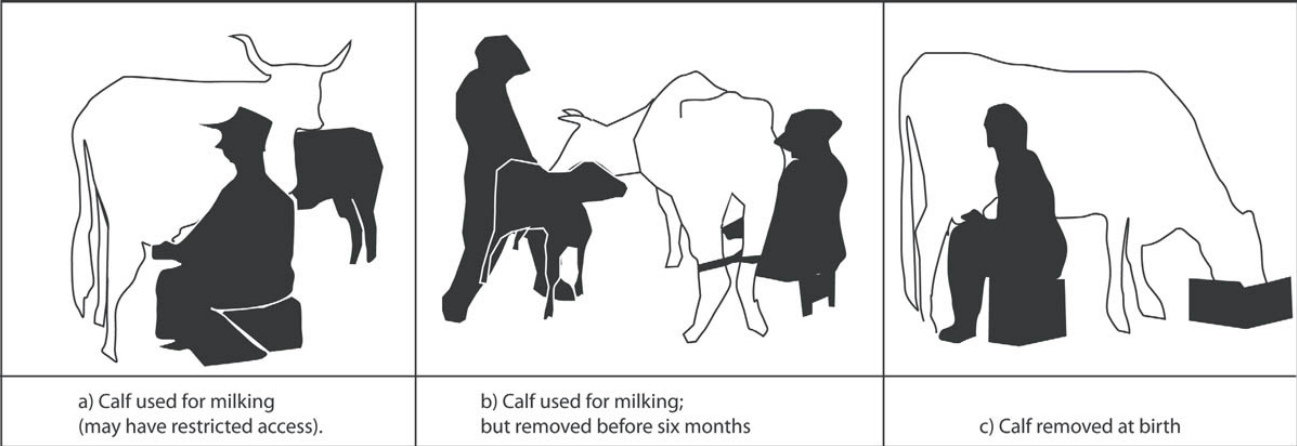


Fig. 16.2. Three types of cattle milking practises: a) calf used for milking (may have restricted access; b) calf used for milking but removed before 6 months; c) calf removed at birth.

Milk let down can also be maintained by establishing a regular milking routine in a relatively stress-free environment (Bruckmaier *et al.* 1997; Labussière 1999). It has been recognised since historical periods that changes to housing environment or husbandry practices can cause stress to cows and affect their let down ability. In the sixteenth century authors recommended that girls with soft hands and gentle disposition should be chosen as milk maids. This was to be coupled with the singing of soothing songs to encourage the milk flow (Fussell 1966; Lucas 1989). The gentle manner was again encouraged by a later writer, who stated that a successful dairy relies on ‘a quiet good natured man with a strong wrist’ (Welton 1852, 12). Modern studies have also demonstrated that feeding during milking reinforces the oxytocin release. Supplying fodder increases milk production and flow, and shortens milking times and stress levels (Uvnäs-Moberg *et al.* 2001; Fig. 16.2c). Finally, primiparous cows, i.e. those with their first calf, show less maternal instinct and consequently can be more easily accustomed to being milked without the calf (Le Neindre 1989). Considering this evidence together, it is not unfeasible that ‘unimproved’ cattle could be encouraged to let down milk without the presence of the calf.

New research into young calf slaughter

One aspect of my project within the LeCHE project was the identification of possible specialised cattle dairy husbandry where young calves are deliberately culled (<6 months). This ‘intensive’ slaughter was proposed to increase milk available for human consumption similar to what is seen in modern dairy systems (Vigne 2003; Vigne and Helmer 2007). An initial problem is differentiating between deliberate slaughter and natural mortality. In general, most natural calf deaths occur in the first one to two days and are due to poor husbandry (Mellor and Stafford 2004). Identifying this relies on accurate aging of dental development stages, particularly during the eruption process and initial wear of M1. The Gillis *et al.* (2013a) method can differentiate between natural mortality and deliberate slaughter. This method has been applied together with Legge’s (1992) dental age determination scheme to material from two Early Neolithic sites in the north-western Mediterranean: Trasano (sixth millennium BC) and La Draga (sixth–fifth millennium BC; Gillis *et al.* 2014). In the study, we have identified the slaughter of calves

between 4 and 6 months at both sites, which can be differentiated from natural perinatal mortality. Research on lipids carried out by Salque *et al.* (2012) has demonstrated that farmers in the Mediterranean area were processing milk during the Neolithic. There is no evidence of ritual treatment of young calves at these sites, and we propose that calves may have been removed early in the lactation period to increase milk production. It is also possible that the cull was due to, or coincided with, adverse seasonal pressures. The removal of calves during the lactation period to increase milk production in the Neolithic may be considered controversial, just as was the reaction to Legge's first publications (1981a; 1981b). However, there is increasing evidence that Neolithic farmers practised sophisticated animal husbandry (Vigne and Helmer 2007; Blaise and Balasse 2011; Gillis *et al.* 2013b). Consequently, the proposal that calves were removed during the lactation period to increase milk production in prehistoric societies may not just be 'milking the evidence' (Legge 1989).

Final thoughts

Tony Legge was an inspiration to several generations of archaeozoologists and his contribution to the practices of archaeozoological research will continue to be important. However, his research into the accurate aging of calves is often overlooked. It has been shown that his 1992 dental age scheme provides more accurate age determination than traditional methods (Gillis *et al.* 2013a). Where suitable material survives, the combination of Legge's method with that of Gillis *et al.* can further improve our understanding of natural mortality and calf slaughter. The rate of natural mortality can be an indication of efficiency of husbandry while the timing of the cull is clearly dependent on the importance of the calf for herd security, milk exploitation and external pressures such as final productive output and fodder demands. This can be seen in modern farming and historical sources show that it was also important for farmers in the past.

Stable isotope analysis can confirm suckling/weaning status of animals and can be used as a proxy for dairy husbandry. Stable isotope studies of different modern dairy husbandry practices could provide references for analyses of archaeozoological material. The Legge dental scheme is important for stable isotopic studies of the weaning process. Further studies of archaeozoological material using accurate age-at-death methodologies for calves and stable isotope analysis will improve our understanding the role of the calf for milk production and the evolution of dairy husbandry. Tony Legge is sadly missed by the whole community, but he did live to see it that established in archaeological thought that dairy husbandry was a significant part of the early prehistoric communities.

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Rethinking dairying in the Irish Iron Age: evidence from Dún Ailinne

Pam J. Crabtree

Introduction

It is a pleasure and an honour to be a part of the memorial volume for Tony Legge. I had known Tony for a long time because we had shared interests in Epipaleolithic settlement and subsistence in the Levant and in the later prehistory of the British Isles. Since we lived on opposite sides of the Pond, I did not have the opportunity to see Tony often, but we ran into each other at conferences every few years. The last time I saw Tony was in the zooarchaeology laboratory at Cambridge in January of 2006. I was in the UK to work on some of the animal bones from the Late Roman site of Icklingham in Suffolk, and Tony was busy entering faunal data from Abu Hureyra on a PC. After the usual pleasantries, Tony commented on the recent publication of the paper by Copley *et al.* (2003) on ceramic evidence for dairying in the British Neolithic and how this represented a degree of vindication for a number of us who had argued for early dairying in the British Isles. In the spirit of that final conversation that I had with Tony, I would like to revisit the question of dairying in the Iron Age one final time.

The question of dairying in the Iron Age in Ireland is a particularly challenging one in terms of the archaeological and the zooarchaeological record. Despite a wealth of developer-funded archaeology carried out between 1990 and the start of the Great Recession in 2008 and the establishment of the Late Iron Age and ‘Roman’ Project by the Discovery Programme in Ireland in 2011, the Irish Iron Age not as well known as the subsequent early medieval period (c. AD 450–1100) or to the Bronze Age that preceded it. While the Irish Iron Age may no longer be the ‘enigma’ that Raftery used to describe it 20 years ago (Raftery 1994), we still do not know as much as we should about settlement, subsistence, and technology in Iron Age Ireland. The new data have been recently summarised by Soderberg (2013). Despite nearly 20 years of intensive archaeological research, we are still lacking large-scale excavations of rural settlements and large, well-analysed faunal assemblages from the Iron Age settlement sites.

Much of the progress that has been made in the study of early dairying has come through the analysis of ceramic residues. In addition to the pioneering work by Copley *et al.* (2003) revealing traces of dairy products on ceramics from Neolithic sites in Britain, more recent work has identified traces of dairying on ceramics from north-west Anatolia and, most recently, on the ceramics from the Linearbandkeramik in Poland (Evershed *et al.* 2008; Salque *et al.* 2013). These data could be

interpreted to suggest that dairying was part of the Neolithic package that spread to Central Europe in the sixth millennium BC. The problem we face in addressing the Irish data is that the Irish Iron Age and the subsequent early medieval period are basically aceramic. This takes away one of the most powerful tools that we could use to identify early dairying in the Irish Iron Age.

A second possible line of evidence is the historical and literary record. Although historical evidence for the late Iron Age in Ireland is limited to some brief mentions in classical texts and a few possible early Ogham inscriptions, early medieval Ireland is home to the oldest indigenous literary tradition in Europe outside Greece and Rome. The law tracts, most dating from the eighth and ninth centuries, provide extensive evidence for early Irish farming (Kelly 1997), and they are supplemented by saints' lives and other historical and literary tracts. However, the question of how much these early medieval documents can tell us about life in the Late Iron Age is a highly contested one. In the 1960s and 1970s, it was generally accepted that the early medieval documents provided a 'window on the Iron Age' (see, for example, Jackson 1964). However, beginning in the 1980s this 'traditionalist' model was replaced by a 'revisionist' one (Wailes 2004). Scholars such as Mytum (1992) argued that Ireland was so changed by contact with the Roman world and by the introduction of Christianity in the 5th century that the early medieval documents should not be seen as a guide to later Iron Age society in Ireland (see also Mallory 1992; 1993; McCone 1990). In some ways, the debate over dairying in the Iron Age is part of this broader theoretical debate (see, for example, Crabtree 1986; McCormick 1991; 1992).

Given the absence of ceramic data for the Irish Iron Age and absence of contemporary historical, literary and pictorial evidence, we are left with the existing Iron Age faunal collections themselves. As noted above, we lack the necessary well-collected and well-analysed faunal assemblages from Iron Age rural sites that would allow us to study animal husbandry practices in great detail. Despite the intensive archaeological research that has been conducted since the 1990s, the largest Iron Age faunal assemblages in Ireland still come from the so-called royal sites.

The Irish royal sites

The Irish royal sites are generally grouped together in the Irish early medieval documents (Grabowski 1990; Johnston 2006). They are identified as places of assembly, inauguration, and kingship. These sites include Dún Ailinne (Co. Kildare) in Leinster, Tara (Co. Meath) in Meath, Emain Macha (Co. Armagh) in Ulster, and Rathcroghan (Co. Roscommon) in Connacht. Although they are described as seats of kings in the early medieval literature, archaeological evidence indicates that they were non-residential. These sites are generally part of larger prehistoric landscapes. They are located on high points (either natural or artificial) and surrounded with an inverted bank and ditch. The bank is located on the outside of the ditch, as it was in earlier prehistoric henge monuments. The interior of these monuments include substantial timber constructions.

The most extensively excavated of the four sites is Dún Ailinne, which was the subject of a major programme of excavation between 1968 and 1975 (Johnston and Wailes 2007). Major excavations have also been carried out at Emain Macha (Waterman 1997). While smaller-scale excavations have been carried out at Tara, the site and its surrounding region have been the subject of detailed archaeological survey (Newman 1997). Intensive geophysical surveys have also been conducted at Rathcroghan (Barton and Fenwick 2005; Waddell *et al.* 2009).

Eight seasons of excavation at Dún Ailinne revealed a complex sequence of timber construction during the Iron Age. The earliest (White Phase) construction was a simple circular ditch that would have held upright wooden posts. This was replaced by a more complex Rose Phase structure that

included a figure-of-eight structure that was marked by three concentric trenches carrying upright wooden posts and a long, funnel-shaped entrance. This complex was surrounded by a larger enclosure which was identified through magnetometry (Johnston *et al.* 2009). These structures, in turn, were replaced by the Mauve Phase structures that included a central circular feature, a ring of upright posts, and an outer circle marked by two concentric trenches that held upright posts. All three of these structural phases may have been constructed and demolished in within a few generations. The nature of the site changed after the destruction of the Mauve Phase structures. The final phase of activity at the site is marked by periodic ritual feasting. A large portion of the faunal material that was recovered from Dún Ailinne dates to this final phase known as the Flame Phase (Crabtree 2003; 2007).

Faunal remains from the Irish royal sites

Large faunal assemblages have been recovered from Dún Ailinne and Emain Macha (McCormick 1997), and a smaller collection of animal bones has been recovered from Tara (McCormick 2002). All three assemblages have been interpreted as evidence for ritual feasting (McCormick 2009), and all these assemblages are characterised by a mix of expensive and unusual meats. In terms of NISP, the Dún Ailinne and the smaller Tara assemblages are dominated by cattle, while the Emain Macha assemblage is dominated by pig. Sheep are poorly represented in all these assemblages, although they were undoubtedly an important part of the general, day-to-day Iron Age economy. Bones of horses and dogs were recovered from all three sites, although no dog bones from Dún Ailinne were recovered from the Flame Phase deposits. The Tara assemblage included over 9% dogs based on NISP (Fig. 17.1), and a number of these bones included traces of butchery. Butchery traces were also seen on some of the horse bones from Dún Ailinne. In the early medieval literature Dún Ailinne is identified as an *óenach*, a gathering of a quasi-ritual nature or a place where these gatherings took place, and Hicks notes that these places have an association with both dogs and horses (Hicks 2007, 186–187).

In addition to the butchered horse and dog bones, the Irish royal sites have produced a number of other unusual faunal finds. A striking feature of the Dún Ailinne animal bone assemblage is the large number of very young calves that were slaughtered at the site. Perhaps the most unusual find is the recovery of the remains of a Barbary macaque (*Macaca sylvana*) at Emain Macha.

Seasonality of slaughter at Dún Ailinne

Hicks (2007) has drawn on evidence from folklore and myth, as recorded in the early medieval Irish literature, as well as landscape archaeology to understand the role of Dún Ailinne and the surrounding sites in late prehistoric ritual and society. Hicks (2007, 192) suggests Dún Ailinne and the surrounding sites were associated with the growing season, the period between Imbolc (1 February) and Lughnasa (1 August) with Beltane (1 May) in the middle. As noted above, the Dún Ailinne faunal assemblage was dominated by the remains of cattle, and many of these animals appear to be quite young. I wanted to determine whether we could use these very young animals to determine the season(s) that rituals and feasts were conducted at Dún Ailinne.

One of the problems I faced in the analysis of the Dún Ailinne fauna was that many of the young cattle mandibles were broken. As Legge (1992) noted, the mandibles of many of these young cattle tend to break around the deciduous fourth premolar (dp4). The depositional history at Dún Ailinne indicated that the Flame Phase deposits resulted from a series of episodic feasts. Many showed some degree of weathering, indicating that they were not rapidly buried. In addition, the faunal remains

from the Flame Phase contexts had been examined by a number of other analysts before I took over the project, and this made it more difficult to reconstruct the broken mandibles, since some of the original small archaeological contexts had been combined into larger units which made reconstruction more difficult. As a result, I relied primarily on the wear seen on individual teeth (primarily the dp4 and the M3) in an attempt to determine the ages at death and possible season of slaughter for the Dún Ailinne calves.

The distribution of the wear stages seen on the Flame Phase Dún Ailinne cattle teeth are shown in Figure 17.2. Using the tooth wear states and age classes as defined by Legge (1992), 29 of the 57 ageable deciduous fourth premolars from Flame Phase show no wear or enamel wear only. These cattle would be assigned to Legge's Stage 1 and would have been between 0 and 1 month old when they were slaughtered. Twenty additional cattle teeth could be assigned to Grant's (1982) wear stages b through f. These animals can be assigned to Legge's Stage 2 and would have been between 1 and 3 months when they were slaughtered. March is the modal birth month for calves in Ireland, with large numbers also born in February and April. Using Legge's ageing data, most of the Dún Ailinne cattle would have been slaughtered between the vernal equinox and the summer solstice. The midpoint between these two dates is Beltaine.

A possible association with the period around Beltaine is interesting for two reasons. First, the name Beltaine refers to Bel's fire. 'At this time two fires were traditionally built and the herds and flocks were driven between them (to confer protection from disease and injury) and off to the summer pastures' (Hicks 2007, 190). In addition, while the Rose Phase structures at Dún Ailinne appear to be oriented toward the equinox, the Mauve Phase structures appear to be oriented toward the Beltaine/Lughnasa sunrise (Hicks 2007, 193).

Dairying in the Iron Age

Without ceramic residues and in the absence of large faunal collections from rural settlement sites, it is hard to make a strong case for dairying in Iron Age Ireland. However, it may be possible to make a circumstantial case for Iron Age dairying based on the available evidence. The first piece of circumstantial evidence is the ceramic residue data for dairying in the British and continental Neolithic. Just over a decade ago Copley *et al.* (2003) provided ceramic residue data that showed clear evidence for dairying in the British Neolithic. More recently, Salque *et al.* (2013) have provided evidence for cheese-making during the LBK in Central Europe. These suggest that dairying might have been part of the Neolithic 'package'. Given the archaeological evidence for contacts between Britain and Ireland from the Neolithic onward, it is unlikely that dairying was a late development in Ireland (*contra* McCormick). McCormick (1992, 208) suggested, but did not make a case for, the possibility that dairying was introduced to Ireland by the Romans. This possibility seems particularly unlikely since osteometric data provide no real evidence for size changes in cattle between the Iron Age and the early medieval periods. In particular, Irish late Iron Age and early medieval faunal assemblages do not have evidence for the large Roman cattle that are found on Roman sites in Britain (e.g. Crabtree 2010) and at sites on the European continent that were either under Roman control or in direct trade contact with the Roman Empire (e.g. Teichert 1984). On the basis of what we now know, it seems reasonable to suggest that the cattle that were slaughtered at Dún Ailinne were drawn from herds that were kept, at least in part, for dairying, although this is something that we cannot prove conclusively.

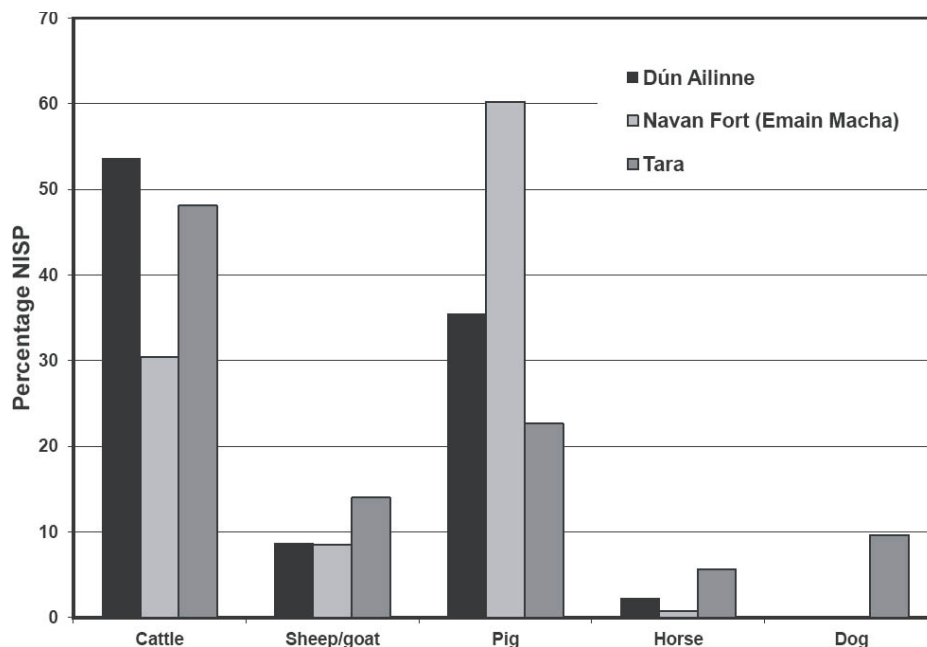


Fig. 17.1. Species ratios based on NISP for the large domestic animals from Flame Phase deposits at Dún Ailinne, Emain Macha (Navan Fort), and Tara. Data sources: McCormick (2009); Crabtree (2007).

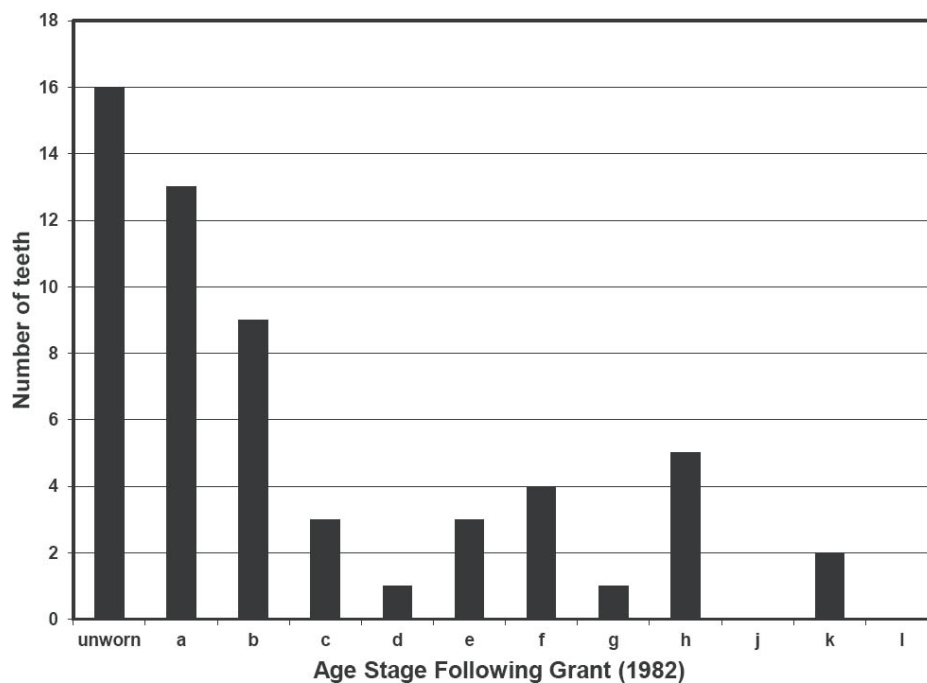


Fig. 17.2. Age stages for cattle dp4s from Flame Phase deposits at Dún Ailinne, following Grant (1982).

We should, however, not expect the faunal assemblage from a site like Dún Ailinne to be a direct reflection of animal husbandry practices. What we see at Dún Ailinne are animals that were slaughtered and consumed for ritual purposes. The slaughter of a large number of young calves shows that the consumption of veal was part of the rituals that were held periodically at Dún Ailinne. As McCormick (1991; 1992) has pointed out, the Irish historical sources indicate that the presence of a calf was necessary for a cow to let down her milk. The historic sources are supported by physiological data on the way a cow's milk is stored in its mammary glands which make it harder for cows to let

down their milk in the absence of a calf (Balasse 2003). The calves recovered at Dún Ailinne are not perinatal mortalities. They were driven to the site and slaughtered there. The choice to slaughter these animals represents a significant sacrifice of both meat and future milk yield. However, this sacrifice may be part of the springtime rituals, like the ones historically conducted at Beltaine that were designed to ensure the health and safety of the herds and flocks. In addition, it is important to note that these calves would have been drawn from a number of different herds over a number of years. While the loss of a number of very young calves from a single herd in a single year might be devastation, the loss of these calves from many different herds over a number of years would have been less serious. The slaughter of these young calves at Dún Ailinne points to the use of the site in the late spring/early summer. These data are consistent with the mythological, literary, and landscape evidence that links the festivals at Dún Ailinne to the growing season.

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Answering zooarchaeological questions from the analysis of animal bones and organic pottery residues: a critical comparison

Alan K. Outram

Introduction

One of many zooarchaeological advancements made by Tony Legge was his early recognition of cattle husbandry patterns in the British Bronze Age that were suggestive of a significant level of dairying (Legge 1981a; 1981b). His work on Grimes Graves built on methods developed by Higham and Message (1969) and Payne (1973) to show that the cattle herds at that site appeared to be strongly geared towards the specialised production of milk, not just the presence of some dairying (Legge 1981a; 1981b). Subsequently, through the 1990s, Richard Evershed's organic geochemistry group at the University of Bristol developed methodologies for the identification of absorbed lipid residues in ceramics using fractionation in stable isotopes of carbon as a proxy. One of the most significant successes stemming from that work was the ability to identify ruminant milk residues in prehistory (Dudd and Evershed 1998). The following year, prehistoric milk protein residues were also identified by an immunoassay method (Craig *et al.* 2000), but it was the lipid method, largely because of better preservation, that yielded widespread evidence of milk in ceramics from the Neolithic onwards, within Britain (Copley *et al.* 2003). Given the widespread view at the time that the 'secondary products revolution' (Sherratt 1981; 1983) was a Bronze Age phenomenon, these results produced a degree of surprise amongst some.

In the following years, a large sample of prehistoric ceramics, from a wide range of British sites, was analysed for absorbed lipid residues leading to separate publications on the Neolithic, Bronze Age and Iron Age (Copley *et al.* 2005a; 2005b; 2005c). This work showed that very high proportions of pottery vessels contained milk in all periods, even the in the very earliest Neolithic (Copley *et al.* 2005a). Legge (2005), in reflecting back upon the osteological evidence for dairying, discussed the recent residue discoveries. In one sense he was clearly pleased that a new form of evidence had validated his claims for significant dairying in prehistory, as there had been objections raised to his interpretations (Legge 2005, 12), but at the same time he was clearly very worried about the extent to which lipid residues really quantified milk use or merely demonstrated its presence or absence. It is clear that he thought that herd structure analysis would still be essential in understanding economic strategies and he was evidently concerned about simplistic assumptions being made from residue results alone (Legge 2005, 12). Following on from Legge's concerns, this chapter aims to critically

consider the different types of information that can be gained from the study of both animal bones and lipid residues, particularly in terms of quantifying contributions made to diets by different animal products. Since 2005, there have been a number more studies integrating osteological and residue analyses as part of a holistic zooarchaeological study, including some involving the current author (e.g. Outram *et al.* 2008; 2011; 2012), so the time is ripe to return to some of Legge's questions and reflect upon them.

This chapter is not intended to duplicate detailed consideration of lipid residue methodology, as the method's originator has summarised this information himself (e.g. Evershed 2007; 2008a; 2008b), but instead it concentrates on zooarchaeological interpretation, and draws out the different methodologies' strengths and weaknesses in relation to a variety of questions. Such a holistic consideration could, and perhaps should, be extended to include stable isotope studies of human remains, aimed at dietary reconstruction, but there is insufficient space to do so here, and some commentary on similar issues, in relation to that topic, can be found elsewhere (e.g. Bogaard and Outram 2013). Whilst focus will be on lipid residues, as the most commonly applied method, appropriate reference will be made to protein residue work where relevant. Below, a series of key issues and zooarchaeological questions will be discussed with respect to both methods, before drawing out some conclusions.

Key issues and questions

Identification and reference material

Before moving on to discuss issues of interpretation and economic reconstruction, it is first essential to consider the basics of identifying faunal remains to species, and residues to taxonomic groupings and product types. In zooarchaeology, identification of bone fragments is largely achieved through morphological recognition by the analyst who is aided by the use of reference collections of modern specimens, comparison with more complete examples within the ancient collection itself, and bone identification manuals or atlases designed for the purpose (e.g. Schmid 1972; Cohen and Serjeantson 1986). Identifications can, in most cases, be made to species level based upon morphology, but metrical analysis is sometimes employed additionally, such as in the case of differentiating sheep and goats (e.g. Boessneck 1969; Payne 1969). There is no doubt that accuracy depends, in no small measure, upon the skill and training of the analyst, and the availability of appropriate reference materials for the geographical region and time period being studied. There is always a risk that uncommon species, in particular, will be overlooked and misclassified. There has been recent increase in research into using methods such as collagen finger printing (e.g. Buckley *et al.* 2014) or bulk ancient DNA screening (e.g. Murray *et al.* 2013) to aid identification of difficult to differentiate species or highly fragmented assemblages.

In relation to lipid residues, whilst some plant and animal products, like beeswax or various tree resins, can be identified by the presence of a particular molecular biomarkers (Evershed 2008b), animal fats require the determination of carbon stable isotope ratios, in order to establish taxonomic groupings or type of animal product. The method used is compound-specific; C_{16:0} and C_{18:0} fatty acids are isolated, because they are the most abundant molecules to result from the degradation of animal fats, and $\delta^{13}\text{C}$ values are determined for each (Evershed 2008b). When these values are plotted against each other on a graph it is clear that separation can be made between ruminant adipose fats and milk fats (Dudd and Evershed 1998), because of the different metabolic processes involved in the laying down of body fat in relation to that produced by mammary glands (Mukherjee *et al.* 2005). Whilst ruminant

cattle, sheep and goats (and other ruminants) cannot generally be differentiated by species, other non-ruminant species with different metabolic systems can be, such as pigs (Evershed 2008b) or horses (Outram *et al.* 2009). Reference $\delta^{13}\text{C}$ values are obtained through studying an appropriate sample size of modern animal fats from animals in the region to be studied (fed on local, indigenous plant materials, if at all possible). The current author has experience of obtaining a wide variety of samples for doing just this, in Kazakhstan, in advance of a project there, by systematically visiting a wide range of local farmers and markets (Stear 2008; Outram *et al.* 2009). Figure 18.1 provides an example of a plot of $\delta^{13}\text{C}$ values from Kazakhstan, where the ellipses represent modern reference data and the dots represent determinations from residues from the Bronze Age site of Dongal (see Outram *et al.* 2012 for more details). When there are large-scale differences in environment, climate and vegetation types, $\delta^{13}\text{C}$ values of different products can all shift, making reference work in the region concerned quite important. One way to mitigate this problem is to calculate $\Delta^{13}\text{C}$ values ($\delta^{13}\text{C}_{18:0} - \delta^{13}\text{C}_{16:0}$) (Dunne *et al.* 2012) such as to effectively remove the differences in environment and focus on the metabolic causes of differentiating fractionation between the two fatty acids, in different products and species. Separation of ruminant milk, ruminant adipose and porcine fats has been shown to be possible through the use of $\Delta^{13}\text{C}$ values in a wide range of environments where local sampling has been performed, such as Europe and the Near East (Copley *et al.* 2003; Evershed *et al.* 2008), Central Asia (Stear 2008; Outram *et al.* 2009; 2012) (as shown in Fig. 18.2) and sub-Saharan Africa (Dunne *et al.* 2012). However, local reference sets are still important to understand a range of other questions, other species and the effects of admixture (see below).

The key point here is that lipid residue analysis cannot be divorced from its zooarchaeological, environmental, palaeoeconomic and cultural context, as Evershed (2008b) makes clear. Analyses do not simply tell you what was in pots, whatever it that might be, but can only provide answers within the frameworks set by the particular research project, for which appropriate reference material has been studied. Standard zooarchaeological analyses remain essential in providing the appropriate context for framing research design and allowing the establishment of appropriate reference data and protocols for identifying certain products and answering particular questions. In a hypothetical project (deliberately over-the-top, to make the point) where archaeologists believe that polar bear meat was ritually consumed from a particular pottery vessel form, the organic geochemist concerned will not identify bear (let alone polar bear), unless they have been informed of the question in advance and been allowed some considerable time to establish reference data and work on a method for differentiation, if indeed it is possible. Similarly, if there was sufficient preservation, immunoassay techniques (e.g. Craig *et al.* 2000) might be able to identify polar bear protein residues, but they would only be able to do so if an appropriate antibody was available and the analyst knew to use it.

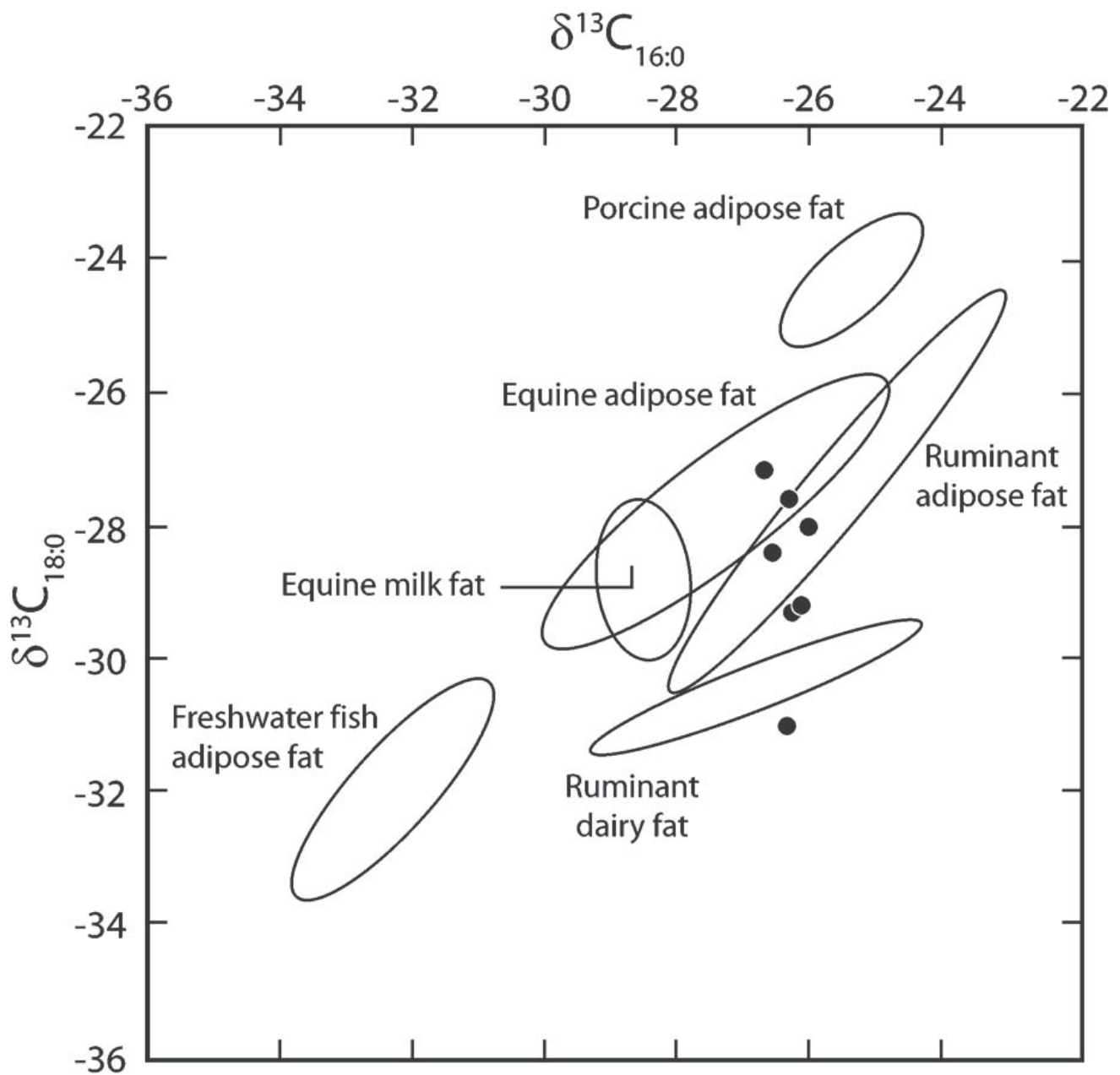


Fig. 18.1. Results of lipid residue analyses on the Bronze Age site of Dongal, central Kazakhstan (Outram et al. 2012). Points indicate $\delta^{13}\text{C}$ values of fatty acid methyl esters of $\text{C}_{16:0}$ and $\text{C}_{18:0}$, whilst ellipses ($p = 0.683$ confidence ellipses, SYSTAT 7.0) represent the $\delta^{13}\text{C}$ values of modern reference animal fats collected in Kazakhstan.

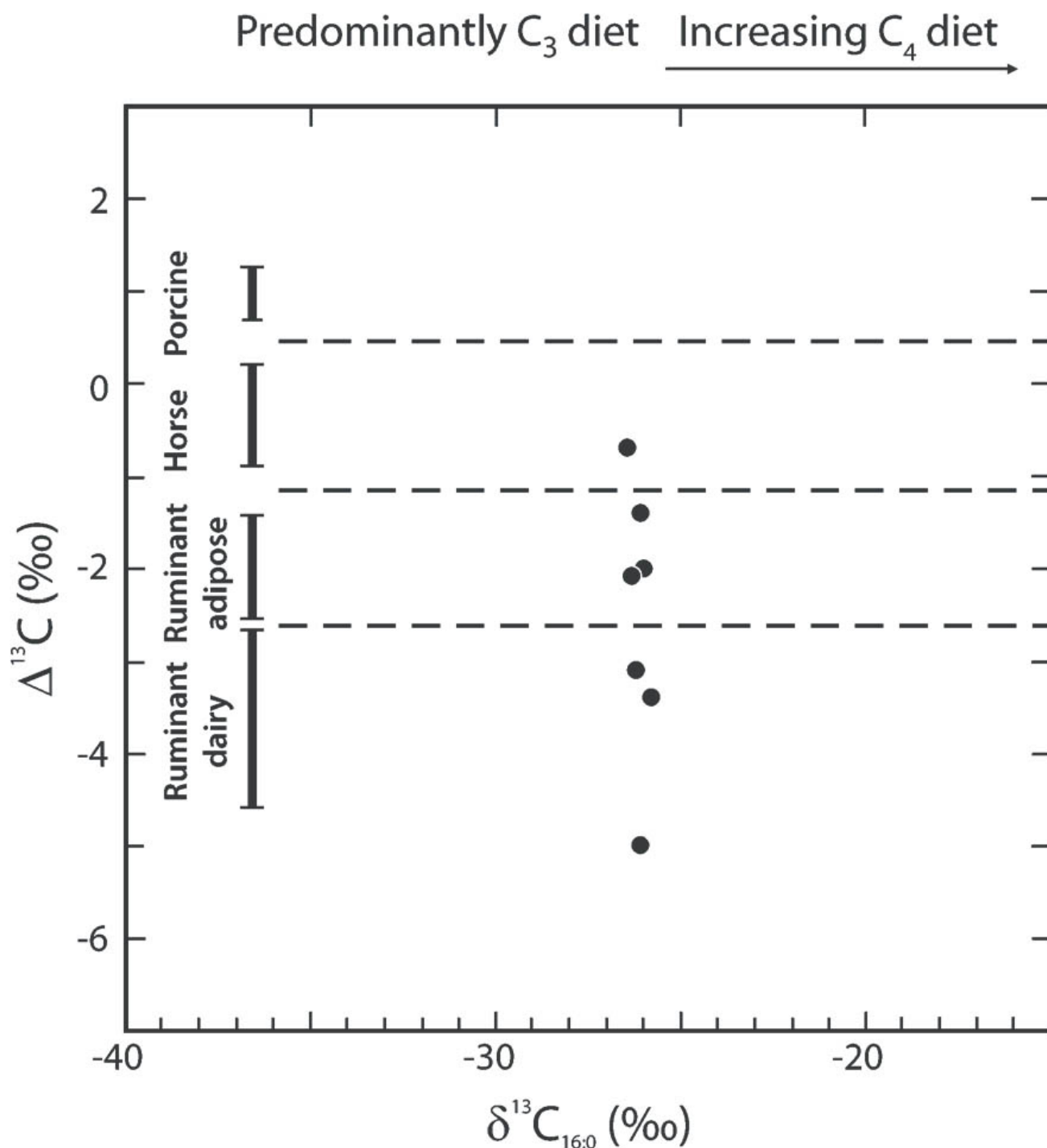


Fig. 18.2. Results of lipid residue from Dongal (Outram et al. 2012) using the alternative method of classifying lipid extracts where $\Delta^{13}C$ ($=\delta^{13}C_{18:0}-\delta^{13}C_{16:0}$) values are plotted against their $\delta^{13}C_{16:0}$ values, with reference materials represented by their $\Delta^{13}C$ ranges. This method of representation can also indicate the relative contribution of C₃ and C₄ plants, or foods from marine environments, to animal diet (Mukherjee et al. 2005).

The critical difference between the two methods is that an alert zooarchaeologist may well be able to identify the presence of unexpected species within an assemblage (though this will indeed be affected greatly by their skill level, assiduousness and willingness to find appropriate comparators), but the organic geochemist has no chance, at present, of doing so without the correct groundwork and appropriate advanced warning of the research agenda. As the range of residue reference data builds, the relationship between zooarchaeology and organic geochemistry will shift and mature, but both will

always mutually benefit from shared intelligence in identifying the most effective protocols to answer important research questions.

Mixed use and blending

Animal bone fragments from different species and anatomical parts are, of course, usually commingled in archaeological assemblages, but they are not ‘blended’ and can be separated out. Mixed and fragmented assemblages clearly present a whole raft of problems in terms deciding what to count and how to draw meaningful quantification from such raw counts. These issues have been eloquently discussed elsewhere (see Ringrose 1993; Lyman 1994; 2008; Reitz and Wing 2008) so need not be revised here. On the other hand, pots can have more than one fatty product stored or cooked within them and the lipids absorbed within their fabric do blend. It is not possible to separate the fatty acids that are derived from a particular cooking ingredient or usage of the vessel, and thus the blend for each fatty acid produces a single integrated $\delta^{13}\text{C}$ value (Evershed 2008a; 2008b). The resulting $\delta^{13}\text{C}$ values will plot somewhere along a line between expected ranges of the two (or more) products involved, in a relationship proportional to the nature of the blend (Evershed 2008b). Such a blending process introduces a degree of equifinality to interpretations of residue results from pottery vessels which have seen mixed uses.

This feature of the method would have serious implications for the usefulness of the technique were it not for two factors. Firstly, many studies have now shown that a high proportion of vessels were actually used for a single purpose, with $\delta^{13}\text{C}$ values plotting firmly within the range for a single product (for examples see Copley *et al.* 2005a; 2005b; 2005c; Evershed *et al.* 2008; Outram *et al.* 2008; 2012). Perhaps it should not surprise us that some unglazed vessels might be kept for particular culinary or storage purposes, perhaps to avoid tainting. Secondly, interpretations can be made in full knowledge of the zooarchaeological data, which is likely to reduce the range of likely options, where there is equifinality. This point speaks once again to the need for holistic consideration of the zooarchaeological and residue evidence.

The above discussion deals with the issue of mixed products in pots, but what happens if a single product is used in a pot on one occasion, followed by different single products on other occasions? It has been suggested that surviving residues might represent particularly the foodstuffs used in the later part of a vessel’s life (Craig *et al.* 2004); however, experimental replication appears to show that earlier and later uses are both represented in the final residue blend (Evershed 2008a). Whilst this process is understood to a certain degree, it is clear that more replicative experimental work would be beneficial in understanding effects of multiple uses, particularly over the *longue durée*. Protein residue analysis (e.g. Craig *et al.* 2000; 2003), which simply produces positive or negative results for the presence of particular proteins, is not affected by the blending problem, and will identify all that is present, provided that the correct antibody tests have been applied. Where preservation of proteins allows, combined use of both residue methods presents another way to clarify issues of equifinality caused by blending (e.g. Craig *et al.* 2003).

Legge (2005) was particularly concerned that there are ethnographic accounts of the use of dairy products to seal unglazed wares, and thus residue evidence for milk might relate to this practical function rather than the vessel’s use for food. This observation is very pertinent; however, if the vessel was then used for a food purpose not relating to dairy products, the vessel would, in fact, produce a blended signal rather than a dairy one. This makes it highly likely that vessels producing clear milk signals were indeed used for dairy products, principally. It is also likely that use of dairy products to seal vessels would still indicate a high level of availability of that foodstuff.

Bias in relation to identifying animal product types

It is obvious that lipid residue analysis can only detect foodstuffs which contain sufficient quantities of mobile fats, waxes or oils to produce sufficient absorbed residues to be analysed. Similarly, protein residue analysis detects only particular proteins' presence or absence. Pots subject to lipid residue analysis that have been variously used to cook meat, store bone marrow or render bone grease will all provide a signature for adipose fat, and will not tell us which of these resources, in particular, was used. A very particular strength of the method has been its ability to specifically identify milk products (Dudd and Evershed 1998), though not the precise form of dairy foodstuff. Whilst their use is reasonably assumed, on circumstantial grounds and through the presence of possible cheese making sieves (Bogucki 1984), direct evidence for very early cultured dairy products is still elusive. One possible line of enquiry, that fermentation might produce enhanced $\delta^{15}\text{N}$ values sufficient to show up in human dietary signals, has not produced results that show a large enough statistical difference (Privat *et al.* 2005).

Whilst not necessarily providing direct evidence for the consumption of particular animal products, zooarchaeological analysis can provide evidence for specialized husbandry related to the production of particular animal products (Legge 1981a; 1981b; 2005) including non-food materials like wool (Payne 1973). However, there is equifinality where the husbandry strategy is not specialized. Procurement of meat can be evidenced by understanding butchery marks observed ethnoarchaeologically (Binford 1978) or experimentally (Seetah 2008), and bone fracture and fragmentation patterns can be employed to identify bone marrow extraction (Outram 2002) and grease production (Outram 2001). As such, viewing the residue evidence alongside husbandry strategies, and evidence from bone processing, sheds further light upon the likely particular products that gave rise to residues, whilst residues help resolve problems of equifinality within mixed husbandry regimes.

One of the most problematic biases relating to lipid residue analysis does not relate to the fact that it detects only fats, but that, in order to leave evidence, the particular foodstuff must have been stored, processed or cooked in ceramics. Clearly that is not always the case. Storage may well take place in ceramic vessels, but one must not forget the large range of organic materials (wood, horn and skin) which may have been used to make containers to hold liquids like milk. Stews will certainly leave residues, and meat can be dry-roasted within vessels; both of these cooking methods have been investigated experimentally in the development of lipid residue techniques (Evershed 2008a). However, roasting can be done in an earth oven or over an open fire, thus not leaving residue evidence in pots. At the British Late Neolithic site of Durrington Walls, scorched ends of bone joints may well indicate that pigs were being roasted with exposure to fire on a regular basis (Albarella and Serjeantson 2002). Lipid residue results from Durrington Walls (Mukherjee *et al.* 2005) show that there are some pots with a pure porcine signal, some with a pure ruminant milk signal, and quite a few more with a likely blended-use signal. It is clear from the faunal report for the site (Harcourt 1971) that pigs are dominant in the bone assemblage. The relatively limited number of pots displaying a pure porcine signal can be explained both through the effects of mixed use of vessels, but also by the possibility that that much pork cooking did not involve ceramics at all. However, the combined consideration of all the evidence cited, along with an understanding of biases inherent within methodologies, produces a very rich understanding of food production and consumption at Durrington.

Quantifying the economic, dietary and cultural significance of species

Having, above, discussed effects of blending and biases on the lipid residue record, and how that record relates to actual foodstuffs consumed, must one think of residue evidence as only providing information

on presence or absence of certain products? A now substantial body of case studies suggests the answer to this is 'no'; lipid residue evidence clearly does provide quantitative data that generally correlates well with the exploitation of particular species. If one compares the proportions of residue types against the proportions of different species of animal bones at a selection of British Neolithic sites (Mukherjee *et al.* 2005, fig. 15), one sees a clear relationship. The proportions are not the same, but as the ratio of animal species present in the faunal assemblage changes, so does the residue information, in a logical and predictable way. In that same study, and also in a significant survey of Near Eastern and SE European Neolithic sites (Evershed *et al.* 2008), it is also clear that there is a statistically significant relationship between proportions of cattle bones and proportions of ruminant dairy residues. In a case study with interesting cultural ramifications, analyses relating to Bronze Age Kazakhstan (Outram *et al.* 2011) show that animal bone assemblages at funerary sites tend to have a high proportion of horse bones within them compared to settlements, something that is quantitatively mirrored in lipid residue results from the different types of sites. Whilst the two forms of record have different biases and formation processes, it is very clear that lipid residues do have a quantitative relationship with species proportions and diet.

Establishing the relative significance of species to economy, diet and culture is an equally difficult task for zooarchaeologists, and one which is not always done well within the field. Even basic failures to take into account animal size and different meat yields are not unheard of, despite the availability of many utility indices etc. (example indices include: Binford 1978; Metcalfe and Jones 1988; Outram and Rowley-Conwy 1998). Dietary significance is not a simple matter of mass either, since calorific and other nutrient values differ according to the portion of the body. Proportions of fat and protein are particularly important, since fat has a much higher calorific value compared to protein by a ratio of 9:4 (Erasmus 1986), and fats' compositions, in terms of saturated versus unsaturated fatty acids, differ by species (Hilditch and Williams 1964) and element of the body (Outram 1998). Another unfortunately common error is the failure to appreciate the difference between 'livestock' and 'deadstock', something Reynolds (1981) draws attention to in his discussion of Butser Iron Age experimental farm, when thinking about the difference between the living farm and what enters the archaeological record. Halstead (2003) also provides valuable discussion of this point with reference to reconciling written records about livestock with the accumulation of dead animals that archaeologists analyse. Unless an entire herd is killed by a disaster, all at once, archaeological assemblages will not mirror live populations, but will build up in relationship to the way animals are selected for slaughter. Different species mature quicker and live shorter lives than others, and hence enter the record at different rates (e.g. see Outram *et al.* 2012), which are also affected by the husbandry strategy being employed and the uses to which the animals are put. All this modelling is necessary simply to describe economic and dietary value, before even considering the plethora of reasons by which animals gain particular significance and value for cultural reasons (as summarised fully by Russell 2012).

It is not a simple matter of regarding zooarchaeology as the principal provider of quantitative information, whilst using residues to identify the presence of key resources like milk. Both provide quantitative data that are highly complex to interpret, but considering both lines of evidence together helps considerably, particularly when dealing with the increased complexity of modelling the contribution of secondary products to an ancient economy. Whilst zooarchaeology can highlight husbandry strategies which suggest a specialized dairy economy, it is much more difficult to quantify the likely contribution of milking within societies with mixed, non-specialised modes of production. In any event, whether killed at the age of 2 years, for meat, or milked for a lifetime, or exploited for wool or labour, a single animal will only ever contribute a single skeleton to zooarchaeological counts. Lipid residues provide us with the opportunity to establish how ubiquitous milk is within the ceramic vessels

of a culture and provide relative ratios of adipose to milk fats that can be compared from one site, culture or time period to another. Whilst that ratio is unlikely to represent an absolute measure of actual food consumption, it has the potential to act as a key proxy for the relative importance of dairying, when viewed alongside husbandry strategy evidence.

Association with material culture and context

Animal bone evidence is rarely directly associated with items of material culture in a truly direct sense, unless the artefact is actually made from a skeletal element. Association with material culture related to food storage, processing, cooking or consumption usually only comes from contextual association, in the same pit, for instance. This does not demonstrate with any certainty that those vessels were used in relation to that animal resource. Such methods as identifying pot polish (e.g. White 1992; Ellis *et al.* 2011), often only used in suspected cannibalism cases, might provide evidence that cooking occurred in pots, but not which ones. Residue analysis makes a direct connection between food products and material culture, which opens a window onto social and cultural questions, as well as contributing to economic understanding.

Residue analysis has allowed us to confirm that *Linearbandkeramik* pottery sieves, long thought by some archaeologists to be for dairying processing, possibly cheese making (Bogucki 1984), are indeed associated with milk (Salque *et al.* 2012). Such work does not always confirm archaeological theories about material culture, however, as a study using both lipid and protein residue analyses (Craig *et al.* 2003) showed that Copper Age vessels from central Europe, often thought to be ‘milk jugs’, in fact rarely contained milk, whilst other vessel types more commonly did. In relation to symbolic aspects of material culture, an examination of British Neolithic Grooved Ware vessels on a range of sites (Mukherjee *et al.* 2008) found no statistically significant relationship between decoration styles and associated commodities. On the other hand, the aforementioned study in Bronze Age Kazakhstan (Outram *et al.* 2011), did establish an association between the use of vessels in funerary contexts and higher proportions of equine residues. The majority of residue studies have so far had primary aims which relate to answering key economic questions, but there is massive potential expand our understanding of the connections between the animal economy and material culture, allowing us to examine the social contexts of consumption with a sound evidence base.

Association with archaeological context is not always a straightforward matter when considering faunal assemblages or pottery residues, but the issues are slightly different. With animal bones, it is not always clear whether deposition relates to the primary function of an archaeological structure, or whether it is the result of later middening. Whilst a feature, such as a pithouse, for instance, may well contain faunal remains that relate directly to its use as a dwelling, and upon abandonment those bones could remain in place, there is also the possibility of later deposition of refuse. This could occur with little time separation, and be indistinguishable stratigraphically.

If one considers the above example from Bronze Age Kazakhstan (Outram *et al.* 2011), it seems at least clear that there may be an association between horses and funerary feasting or depositional practices. However, the animal bones in this case were not formally buried in graves, in most cases, but were generally associated with features surrounding kurgans. The bones are associated, and may the result of feasting or offerings, but their precise function and connection is a matter for interpretation. The relationship of the equine lipid residues to the funerary context is an even more interesting point for discussion. The vessels are usually grave goods and so have a direct association with the mortuary rite. However, the crucial point here is to ask what the residues’ associations are? The residues are directly associated with the pottery vessel, but unless the vessel was produced exclusively for mortuary

purposes, perhaps including feasting or the inclusion of foods as grave goods, then the residues therein could be related to a past use of that vessel rather than to its final funerary use. In this example, it seems highly likely that at least some of the vessels were not new, not least because it is not uncommon to find vessels which have been broken and repaired with bronze staples (see Fig. 18.3). Thus the higher preponderance of equine lipids may relate to mortuary practice specifically, or to a tendency to select vessels which in the past have been used to cook horse. The effort expended in repairing some of these vessels with bronze staples might suggest that the pots chosen held some significance, so the correlation with equine fats could be a more general association with important vessels, and how they are used before their final mortuary deposition. Clearly, the lessons from this case study could be pertinent to others.

Dating and environmental proxies

Bones have, since the early days of radiocarbon, been dateable, and accuracy has been much improved through the use of compound-specific AMS determinations and processes like ultra-filtration (Higham *et al.* 2006). However, compound-specific AMS determinations can also be carried out on fatty acids from pottery residues to produce dates that correlate well with other absolute dating methods (Stott *et al.* 2001; 2003). The date will represent some form of averaging of the time period the pot was in use, as represented by the blend of surviving lipids.

Bones, and particularly teeth, are also well-established carriers of climatic ($\delta^{18}\text{O}$) and geological (e.g. $^{87}\text{Sr}/^{86}\text{Sr}$) proxies that inform us about environmental change and animal movement (e.g. Lang *et al.* 2013). High-resolution sampling in relation to incremental growth in teeth is providing ever more accurate seasonal isotopic sequences (Zazzo *et al.* 2012; Towers *et al.* 2013), which are now being integrated into fine-grained zooarchaeological studies of mortality in relation to understanding husbandry strategies (Gillis *et al.* 2013). Whilst lipid residues do not carry as wide a range of proxies and cannot produce such incremental sequences, they can provide environmental and climatic information through deuterium ratios (δD). δD determinations from lipids have been used as an environmental proxy within peat sequences for some years (e.g. Xie *et al.* 2004), but this approach is now also seeing application to archaeological ceramic residues (Outram *et al.* 2009).



Fig. 18.3. A pot being excavated from a grave at the Bronze Age, Andronovo period site of Temirkash, Kazakhstan. A black arrow points to a bronze staple that was used in the past to repair the pot.

Conclusion

The conclusion to the paper is a simple one. Animal bone assemblages and ceramic residues both provide very valuable quantitative data on the exploitation of animals, and their products, in the past. In both cases, the middle range theory required for effective interpretation is complex, but, because each method has different strengths and weaknesses, projects which come to holistic interpretations from employing both methods will be able solve much more complex research questions than the two sub-disciplines working alone. Residues *are* faunal remains and tell us much about human–animal relations in the past. As such, when residue analyses and a multitude of other stable-isotope techniques, are applied to questions about human exploitation of animals in the past, they should be considered to be an integral part of zooarchaeology. Zooarchaeologists need to understand these method, but, more importantly, assimilate them into their theoretical frameworks for understanding the way the archaeological record forms and how to interpret it.

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Salt, cows, milk, and the earliest farmers of central Europe

Peter Bogucki

Introduction

Archaeologists have long been interested in salt as a prehistoric commodity. It frequently appears in the literature as something to be traded, for which there is ample evidence from later prehistory, which requires its production in bulk and in a relatively pure form, through either mining or evaporation. For this reason, archaeological monographs devoted to salt (e.g. Nenquin 1961; Brown 1980; Lane and Morris 2001, among many) consist primarily of discussions of techniques for salt production and the equipment needed to evaporate brine. Salt-making produced an essential commodity for the preservation of meat and fish that would have moved along the transportation infrastructure that emerged later prehistory.

Recently, several publications have made prehistoric salt extraction a hot topic again (e.g. Alexianu *et al.* 2011; Nikolov and Backalov 2012; Harding 2013; Harding and Kavruk 2013). Most of their focus is on the European Copper Age and later. A notable exception has been the discovery of Early Neolithic salt extraction from brine springs at Poiana Slatinei in Romania dated to the early sixth millennium BC (Weller and Dumitroaia 2005).

While preparing this paper, I learned of a recent article by Eszter Bánffy that discusses salt exploitation in the Carpathian Basin during the sixth and fifth millennia BC (Bánffy 2013). She expands her discussion to include all of central Europe and notes the correlation of areas of Early Neolithic settlement with major salt-producing areas in southwestern and central Germany and southern Poland, suggesting that perhaps this is not a coincidence. A quest for salt as a valued trade good, Bánffy proposes, may have facilitated the development of networks that drew farmers and farming into riverine interior central Europe. Another relevant paper that I was pleased to discover is by John Chapman and Bisserka Gaydarska (2003) who wrote about the relevance of salt for the economy of the Tripolye mega-settlements. It seems likely that salt acquisition was on the minds of Neolithic farmers in temperate Europe from the very beginning.

In this essay, I make common cause with Bánffy, Chapman, and Gaydarska and propose that salt was a key resource for the earliest farmers of central Europe. I am not writing about salt-making or salt as a commodity, however. Instead, I have chosen to investigate, somewhat speculatively, the role that inland saline habitats played in the world of the earliest farmers of central Europe during the sixth and fifth millennia BC. My reason for exploring this issue stems from a question in which Tony Legge

and I had a mutual interest, the practice of dairying during the Neolithic. Dairy cattle need salt at a level higher than that for beef cattle. Neolithic farmers would have needed to find ways to connect them with natural sources of salt that could be ingested yet regulated metabolically, since too much salt is not good for cattle, either. Thus the motivation for this essay.

Tony was very supportive of my interest in Neolithic dairying. At the 1982 ICAZ conference in London, he called my attention to his paper from the 1980 Edinburgh meeting on farming practice in British prehistory (Legge 1981) about which I had been unaware. Writing about the Neolithic fauna from Grimes Graves, Tony pointed out that the proportions of females to males that indicated that the main outputs from the herd were calves and old cows made no sense for a meat economy and that dairying was the likely reason. Our paths crossed altogether too infrequently, but I was glad to spend an afternoon talking with him in Cambridge in 2008 and to see him once again in Amsterdam in 2012, not realising that it would be the last time.

Inland saline habitats

Another motivation to write this essay was encountering a recent monograph by Agnieszka Piernik entitled *Ecological Pattern of Inland Salt Marsh Vegetation* (Piernik 2012) which mentions several key areas of inland saline habitats in Poland. It is illuminating. Piernik (2012, 13) defines inland saline habitats in central Europe as ‘natural sites of inland halophilous vegetation ... connected with areas supported by salty springs and saline ground water.’ After subtracting the anthropogenic saline habitats around modern industrial saltworks, several of the remaining sites that Piernik discusses are surprisingly adjacent to key areas of early Neolithic settlement (Fig. 19.1). I was intrigued.

Three localities in Poland that Piernik mentions are the Zgłowiączka Valley in north-central Poland that drains south-eastern Kuyavia, the Nida basin north-east of the city of Kraków, and the northern rim of the Western Carpathian highlands south-east of Kraków near the towns of Wieliczka and Bochnia. All three are key areas for settlement of the earliest farming communities in this area, the Linear Pottery culture. Several other locations of natural salines that Piernik studied, such as near the town of Łęczyca, do not figure in the story of the Neolithic although they have considerable significance for later prehistoric and early historic settlement. Thus let me be direct and admit that I am cherry-picking the localities that fit my hypothesis and omitting those that do not. *Mea culpa*.

The Zgłowiączka river is a small low-energy stream that flows through the concentration of Linear Pottery sites described in detail by Grygiel (2004) and recently augmented by additional sites to its east discovered through rescue excavations in advance of a new motorway. These sites provided many of the sieve sherds that were analysed for lipid residues by Mélanie Salque at the University of Bristol and which turned out to be rich in bovine milk lipids (Salque *et al.* 2013). Glacial tunnel valleys intersect with the Zgłowiączka corridor and provide pathways into the interior of the adjacent forests (Bogucki *et al.* 2012). The whole area sits on top of the massive Zechstein salt formation that feeds saline springs at spas in Ciechocinek and Inowrocław but which also would have salinised much of the groundwater that emerged at springs throughout Kuyavia and elsewhere in northwestern Poland (see Fig. 19.1, 3a/b). Although the saline habitat studied by Piernik lies upstream from the concentration of Linear Pottery sites near Brześć Kujawski, it is possible that not only did the Zgłowiączka water downstream had an elevated saline content but also that salt springs could have existed near Brześć Kujawski itself during the Neolithic.

The presence of many stands of halophytic vegetation across Kuyavia was documented by Jadwiga Wikroń-Michalska (1963) and in the Zgłowiączka valley in particular by Roman Kobendza (1922). Wikroń-Michalska (1963, 36) notes the presence of elevated saline levels at Rządka Wola, just

southwest of Brześć Kujawski, and Wieniec, about 5 km north. From this literature, it is clear that the presence of halophytic vegetation and thus underlying saline springs or seepage is not confined to a few study sites but rather can be considered to be a broad regional characteristic.

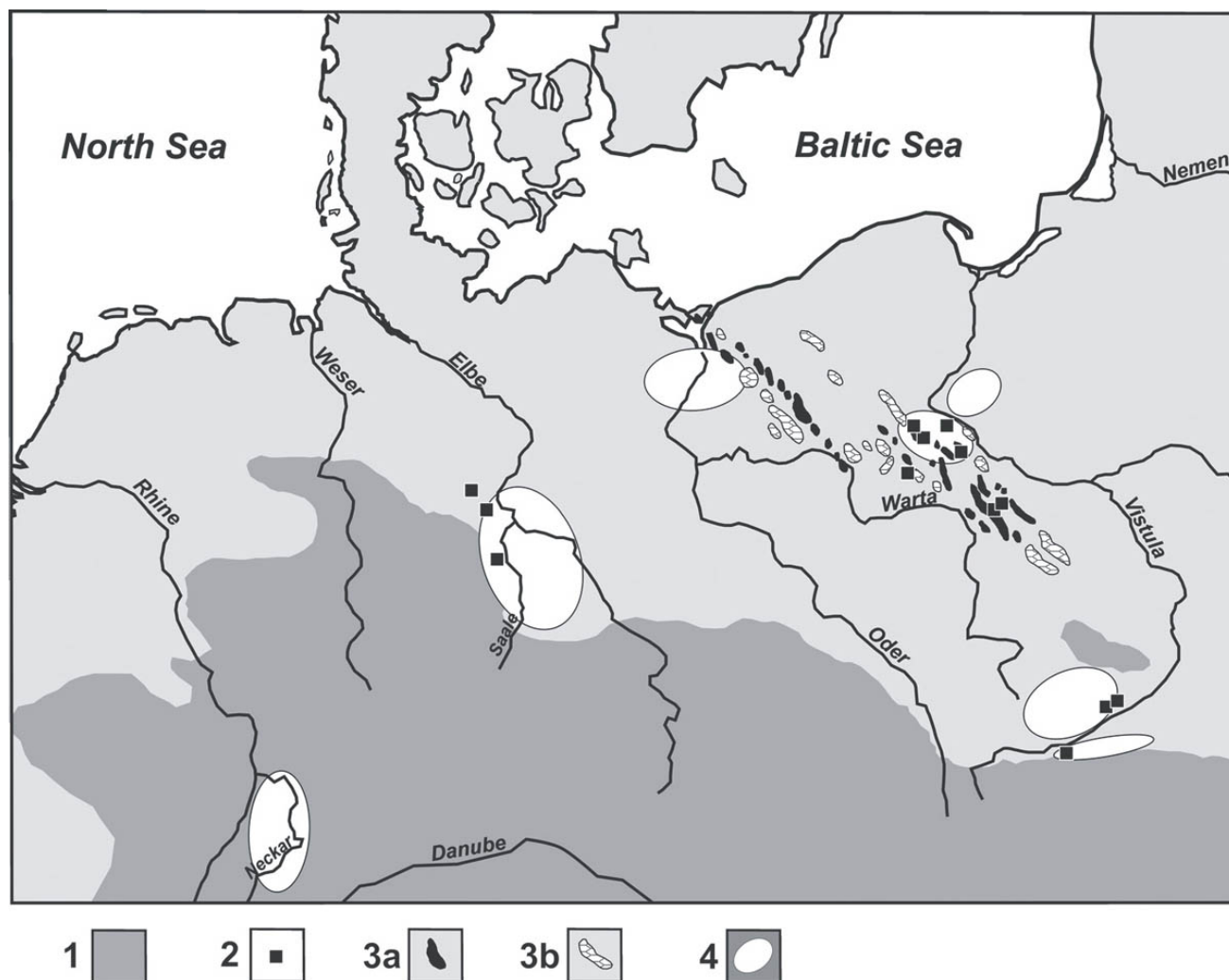


Fig. 19.1. Map of northern central Europe showing relationship between inland saline habitats and early farming settlement. Key: 1 – land over 300 m above sea level; 2 – natural inland saline habitats discussed by Piernik (2012); 3 – Zechstein salt diapirs (after Czapowski and Bukowski 2010), a – pierced through Mesozoic cover, b – non-pierced through Mesozoic cover; 4 – several areas of Early Neolithic settlement particularly associated with saline habitats and brine springs.

The lower part of the Nida valley near Kraków is another luminous area of Neolithic settlement. It is one of several left-bank tributaries of the Vistula river, others being the Nidzica and Szreniawa, that drain the loess basin studied by Janusz Kruk in his classic study of changing Neolithic settlement patterns (Kruk 1973). Clusters of Linear Pottery sites are found along these small streams. Although the specific locality studied by Piernik is downstream from these site clusters, Linear Pottery sites are noted within quite short distances. We can consider the Nida saline habitat to be part of the overall ecumene of the earliest Neolithic farmers of the Małopolska loess.

The saline habitat of the Wieliczka-Bochnia area is already celebrated for the vast salt mine at Wieliczka, a World Heritage Site visited by thousands of tourists every year. Salines are also known

from Barycz. The potential of this area for Neolithic salt production was discussed extensively by Jodłowski in the 1970s (e.g. Jodłowski 1977). What has become clear in the last decade is that this area is also the location of a hitherto poorly-known concentration of Linear Pottery settlement that has come to light through rescue excavations for the A4 motorway. The highway right-of-way has cut a transect through a series of Linear Pottery sites, many of which contain multiple longhouses (Czekaj-Zastawny 2008). The Wieliczka-Bochnia area lies at the southern edge of the Małopolska loess where it begins to slope upward to the foothills of the Western Carpathians. I have referred to this area as the ‘hill country’ (Bogucki 2014) of which the Neolithic settlement is only beginning to be understood. A tantalizing hint of what might lie there comes from upland Linear Pottery settlements at Łoniowa and Żerków (Valde-Nowak 2009).

The map of European salines presented by Ward (1874) is especially illuminating when it comes to identifying concentrations salt springs elsewhere in central Europe, which can then be correlated with areas of Linear Pottery settlement. Two regions are particularly noteworthy in this regard: the Elbe-Saale region of central Germany, home to exceptional concentrations of early Neolithic settlement, and the Neckar valley in southwest Germany, also the location of celebrated Linear Pottery settlements like Vaihingen-Enz. Both of these were also highlighted by Bánffy (2013, 207). In the case of the Saale region, and its central town of Halle, their names that are derived from ‘salt’ say it all. Unlike the mining at Wieliczka, the medieval salt wealth of the city of Halle was based on the evaporation of brine from saline wells. Saile (2012) specifically points toward the Halle-Saale region as a likely location for Neolithic salt production. The Neckar valley has numerous salines and salt mines, as reflected in the name of the town Sulz.

We could extend this exercise indefinitely and inconclusively. The fact is that salt springs and the resultant saline habitats are very widespread in central Europe, and many of them are found in areas of Linear Pottery settlement. There are also many saline habitats that are in areas where Linear Pottery settlement is not found, and many Linear Pottery settlements found some distance from brine springs. So we cannot say that the presence of inland saline habitats was the sole determinant of Linear Pottery settlement distribution. Instead, however, I believe that they could have been a strong consideration in where Neolithic people, or as I suggest below, areas to which the early farmers were drawn because their cattle were attracted to them.

Early Neolithic dairying in central Europe

With the discovery of bovine milk lipid residues in ceramic sieves from Linear Pottery sites in northern Poland (Salque *et al.* 2013), the evidence for Early Neolithic dairying in central Europe has been conclusively substantiated. It should be noted that the primary evidence for this particular study came from sites in Kuyavia, especially those lying along the eastern margin of the Kuyavian plateau, not far from the saline springs in the Zgłowiączka valley. The location of sites like Smólsk and Ludwinowo along the escarpment of the Vistula floodplain raises the question of whether it might be possible to identify saline springs here as well.

The conversion of milk into cheese would have been a significant addition to an agricultural economy otherwise based on cereals, legumes, and meat. Cheese would have been easier than liquid milk to handle, transport, and store. Moreover, it would have been available during the spring and summer, when the bounty of the previous year would have reached exhaustion and the harvest had not yet taken place. The production of ceramic sieves as a dedicated vessel type to cheese manufacture represents a substantial investment in this process, indicating that it was practiced repeatedly and regularly.

Several regions in central Europe have yielded Linear Pottery sieves in greater abundance than others. In my 1984 article (Bogucki 1984), I mapped sites with sieves based on available literature at the time. They cluster in five key areas: Kuyavia, the Elbe-Saale area, the Neckar Valley, the lower Oder valley, and north-eastern Hungary. I had forgotten until now how many sites of the Alföld Linear Pottery with sieves I had recorded in north-eastern Hungary, which provides a topic for further investigation in light of the brine springs of the eastern Carpathians. It was curious then and still is how scarce sieves are in Małopolska in southern Poland in light of the concentration of Linear Pottery settlements there and their proximity to saline habitats.

An area where Linear Pottery sites have consistently yielded sieve fragments but which is very under-studied lies along the lower Oder river, not far from its where it enters Szczecin Bay. Sites lie on both the Polish and the German sides of the river, set back from it on lakes and small streams. Since World War II, very few excavations on Linear Pottery sites have taken place in this region; an exception is Zollchow (Heußner 1989), which has yielded the obligatory sieve sherd. Although this area is not known especially for its salt-making, it lies at the north-western end of the belt of salt diapirs of the Zechstein formation that begins in central Poland and runs across Kuyavia on its way toward the lower Oder (Fig. 19.1).

Salt and cows

Salt is essential for humans, but it is even more essential for herbivores who produce secondary products. Carnivores can satisfy their salt needs from the meat of their kills, but herbivores require salt from the plants they eat and the water they drink. There is an immense literature about the metabolism of salt by animals, much of which can be found synthesised in an immense book by Derek Denton (1982) entitled *The Hunger for Salt*. Denton (1982, 13) states that ‘any animal whose diet contains a large amount of vegetation may seek mineral supplements.’ Chapman and Gaydarska (2003, 203) were perhaps the first archaeologists to make the connection between the active quest for salt by ruminants and a prehistoric economy that used dairy products.

During lactation, dairy cows have very high nutritional requirements compared to other species and to non-lactating animals, and one of the key minerals needed by lactating cattle is sodium. In addition to the usual pathways for sodium loss in saliva, feces, and urine, the amount of sodium that exits the cow in milk must be continuously replenished or else milk yields themselves decline precipitously. According to the National Research Council of the United States, growing heifers need 0.06–0.08% sodium in their diets (calculated as dry matter), while nursing cattle, especially in the weeks right after giving birth, may need as high as 0.34% (Herd and Perry 2011, table 8, based on data from National Research Council 2001).

In the Merck Veterinary Manual Online, Herd and Perry (2011) note the following role for sodium in the diet of modern dairy cows:

Other macrominerals required in dairy cow diets include sodium, potassium, chloride, magnesium, and sulfur. Of these, sodium generally needs to be supplemented, typically as sodium chloride or common salt. Insufficient dietary sodium results in reduced feed intake with subsequent reductions in animal performance. Signs of severe salt deficiency include licking and chewing on fences and other environmental objects, urine drinking, and general ill thrift. Milk production is reduced within 1–2 wk of removing supplemental salt from the diets of lactating cows. Completely withholding salt from dry cow diets in an effort to prevent udder edema at calving is not a good practice. Maintenance requirements for

sodium in nonlactating cows are estimated at 1.5 g/100 kg body wt/day, with gestation requirements estimated at an additional 1.4 g/day after 190 days of gestation. For large-breed dairy cows, this results in a sodium requirement of ~9–10g/day. Unsupplemented dry cow diets seldom provide >3 g/day of sodium. Therefore daily supplementation of dry cow diets with a minimum of 6–7 g of sodium per day (~15–16 g of salt) is important. Additional salt is necessary during heat stress.

It is clear that obtaining enough sodium, as a component of salt, is critical to the productivity of dairy cattle.

Modern farmers provide supplementary salt for their dairy cattle. Aines and Smith (1957) reported a 100% increase in milk yields when sodium-deficient dairy cows were fed a salt-supplement. Neolithic farmers would certainly have noticed a difference in productivity between dairy cows with adequate salt and those with salt deficiencies. Cattle, and ruminants in general, naturally crave salt (Denton 1982; Mehren 2010). They will go to great lengths to seek it out. Denton (1982, 182) reports how cattle can detect sodium solutions by smell and choose them preferentially. In commenting on the attraction of brine springs for animals in modern Romania, Alexianu *et al.* (2011, 19) note that ‘when a damp salt zone is located in the proximity of a village not only the wild animals lick it, but also domestic animals, first of all the bovines.’

The potential relevance of these observations is that it may have been advantageous to allow cattle to pursue their natural craving for salt and graze on halophytic vegetation that flourished in saline habitats and to lick the briny soil, but without drinking overly-saline water. Neolithic farmers almost certainly would have noticed the better productivity of their cows when they grazed in saline habitats, and the natural craving by the cattle for salt would have drawn them to these localities.

The case for open-range grazing

Another thread in this argument is the nature of the cattle management system of the earliest farmers in central Europe. Elsewhere (Bogucki 2013), I have made the case for the practice of open-range or free-range grazing by Linear Pottery communities, in contradistinction to the general assumption of tight human control by confinement in pastures. My suggestion is that most cattle were allowed to seek their own grazing within the forests and glades around Neolithic settlements, to be led or lured back when needed but otherwise not especially supervised. Colonists in the Caribbean and eastern North America, particularly in the Chesapeake region, used such open-range systems (Davis 2000; Anderson 2004), which are particularly useful in situations where labor is scarce and the landscape is wild. Crops were fenced in to keep the animals out of gardens, but otherwise the animals were unrestricted and free to wander

If, and at the moment it is not substantiated and awaits clever analytical advances, Neolithic cattle could range freely in the forests and glades of central Europe, perhaps their inherent nutritional requirements took them to locations where they could be met. Thus, if salt was something that lactating cows required, might it not be possible that they were drawn to saline habitats. Thus my suggestion (Bogucki 2013, 267) that freely-ranging cattle drew Neolithic people along to open up new areas of settlement may be extended to propose that the identification by cattle of such saline habitats was followed by their attraction to early farmers. If cattle in these areas were seen to be better producers of milk than those in less-saline areas, the attraction of the saline habitats to early farmers would have become elevated.

An argument for extensive cattle management in Neolithic central Europe may appear to

contradict the compelling case made by Amy Bogaard (2004) for intensive garden cultivation by the early farmers of central Europe. I do not believe that one contradicts the other, and indeed it is possible that they could be complementary. In fact, compact cultivated plots would be easier to defend against free-ranging cattle than the other way around. Manure for small fields would be provided by the caprines and pigs kept by Linear Pottery communities in small quantities as well as by lactating cattle and their calves lured or led back to the settlements for milking. The point is that the agricultural practices of the earliest European farmers were integrated and probably had a high safety factor, and every habitat that provided an advantage through a combination of attractive features drew early farming settlement toward it, during both initial long-range colonization events and the subsequent infilling of settlement clusters.

Convergence

The goal of this essay has been to expand the discussion of the role of salt in the lives of the earliest farmers of interior central Europe. Rather than thinking of salt only in its solid, crystalline form, either mined or concentrated through evaporation to be suitable for trading and meat preservation, the proposal here is to consider the role of inland saline habitats in which salt could be ingested by ruminants by eating halophytic plants and licking salty soil. Such a natural source of sodium would have been immensely valuable for sustaining and increasing milk yields of dairy cows.

Such a quest for saline habitats in Early Neolithic Europe would have almost no inherent archaeological visibility. The most that can be hoped for is to seek a correlation between the locations of inland saline habitats and Neolithic settlements and to argue a case on logic and inference. To recapitulate my argument: (1) saline habitats are widely distributed throughout interior central Europe; (2) in many places, they map to concentrations of early farming settlements; (3) the inhabitants of these settlements milked their cattle and used dairy products; (4) dairy cattle require higher levels of salt in their diet than cattle raised for meat; (5) if the early farming communities practised open-range grazing, cattle used for dairy production may have gravitated to saline habitats; (6) if early farmers followed their freely-ranging cattle, the combined presence of saline habitats and fertile soil may have made certain areas, such as Kuyavia in Poland, that much more attractive for settlement.

Clearly there are a lot of 'ifs' in this argument beyond the basic facts, and it does not provide a smoking gun that links salt with dairy cattle during the Neolithic. Its goal is to situate inland saline habitats as factors among the countless choices and decisions made by the earliest farmers of interior central Europe about where to locate their settlements and to conduct their economic activity. The key point is that rather than treating salt solely as a commodity to be extracted, processed, and traded in the same way we might consider desirable flint types or amphibolite, we should consider an association between saline habitats and dairy production as a concept that should be investigated further. For example, do Linear Pottery sites in highly-saline environments such as are found in Kuyavia show more evidence for dairying than sites in less-saline areas? There is much yet to be learned about the role of salt in the economy of the earliest European farmers.

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Part IV

Farmers that hunt

Hunting by farmers: ecological implications

Jonathan C. Driver and Shaw Badenhorst

Introduction

In many parts of the world, farmers focus their energies on the production of crops and on raising domestic animals, and it is for studies of these societies that so much of Tony Legge's work will be remembered. Where larger domestic animals can be kept, the role of hunting is usually diminished. However, in some parts of the world farmers made little or no use of domestic animals (other than dogs), and relied on hunting or fishing to provide them with animal protein. Although this pattern is changing as the result of the increased availability of preserved foods and massive alteration of some ecosystems to allow stock raising, these traditional practices are still followed in some regions.

In this paper, we discuss the ecological parameters of hunting in small-scale farming communities where domestic animals were not the primary source of animal protein. We use the term 'farming' to cover any economic strategies where plants were deliberately cultivated. However, because we exclude societies with domestic animals, we thereby exclude people who rely on draft animals for ploughing and most of our examples are drawn from societies that some would classify as horticulturalists. We have excluded exploitation of aquatic animals from our definition of hunting. However, some of the ideas discussed in this paper could be expanded to incorporate aquatic species.

We begin by acknowledging two important theoretical issues that must be borne in mind in any attempt to develop a general model or draw general conclusions. First, in dealing with human ecology, one must remember the diversity of human behaviours known from the ethnographic and archaeological records, as well as the complexity of environmental responses to human disturbance. Numerous factors contribute to the interactions between human subsistence practices and local habitats. For example, Jackson and Scott (2002) identify phenomena such as the local environment, the scheduling of activities, technology, types of cultivation, human demography, and settlement structure (including degree of sedentism). Second, although we may be able to find patterns or regularities in the archaeological and palaeo-environmental records, natural and cultural situations are unique, and contingent on the individual histories of particular cultures and landscapes. This concept is well understood within the disciplines of archaeology (e.g. Hodder 1986) and ecology (e.g. Brown *et al.* 2001). However, as Netting (1993) argues, we need not abandon generalising approaches, particularly if we recognise that interpretations must include a more comprehensive understanding of the individual historical trajectories of humans and their environments. A similar point was made by Winterhalder and

Smith (2000) in their review of the anthropological use of models derived from behavioural ecology. We attempt to develop some general models of hunting and its ecological impact in farming societies that lack domestic animals. We also outline some of the circumstances under which these expectations may not be met.

A number of themes commonly characterise discussions about the ecology of hunting in farming societies, and these form the focus for discussion in the remainder of this paper. The three themes are:

1. habitat modification;
2. the depletion of large game;
3. 'garden hunting' as a response to points 1 and 2;

The impact of farmers on habitats

Habitat modification

There is ample evidence that hunter-gatherers modify their environments, either deliberately or as an unintentional by-product of other behaviours. For example, hunter-gatherers use fire to manage plant communities, construct many different kinds of traps and game driving systems, relocate plant and animal species, divert streams and cause animal population depression and occasional extinctions (Cohen 1977, 20–23). Smith (2011) documents six major categories of environmental modification to enhance human subsistence ('niche construction') in non-agricultural societies. However, farmers generally modify local environments to a greater extent than their hunter-gatherer ancestors or neighbours.

Harris (1969) provided a general ecological model for farming, noting that natural ecosystems often became more specialised and less diverse when transformed by people. Less commonly, a specialised ecosystem might become more generalised. Alternatively, ecosystem complexity might remain constant, with substitution of wild species by domesticates. Within this general model there is a wealth of more specific changes that farming might produce, and the list outlined below (summarised mainly from Butzer 1982, 123–131) gives some indication of the scope of the impact of farming generally. For instance, the creation of gardens and fields involves clearance of existing vegetation. Local and imported crops are planted, resulting in novel associations of species. Preparation of land for planting may create good germination conditions for other species, resulting in increased populations of weeds. Plant species selected for cultivation often have high productivity, making them attractive food for animals. Cultivated areas may be surrounded by boundary markers, such as ditches, walls and hedges, each forming a microhabitat. Irrigation or drainage systems result in standing and running water. Hydrology, sediments and soil conditions can also be changed by farming practices. Once a field or garden is abandoned, it will be colonized by associations of plants and animals that may differ from the associations that preceded the farming activity.

Habitat modification by farmers has been a recognised element of the archaeological record for many years. In an early example, Clark (1947) reviewed palaeo-ecological and archaeological evidence from Western Europe to show that forest clearance had been occurring since early prehistoric times. Forty years later, Delcourt (1987) reviewed the ecological effects of early agriculture, mainly using palynology. She identified four major effects of prehistoric farming: a change in the composition of forests; a modification in the range of wild plant species; a formation of disturbed areas that favoured pioneer species; and a change in the landscape mosaic, especially through the creation of clearances within forests. Recent archaeological work has focused on more detailed documentation of farming

practices, often at quite small scales (e.g. papers in Chambers 1993; Robinson 2003; Prosch-Danielsen and Sangren 2003). Archaeologists have also shown that some ancient farming practices created artificial habitats which do not appear to possess modern natural equivalents (e.g. Erickson 1992). Hayashida (2005) demonstrated that anthropologists and archaeologists now have a much better understanding of the complexity of this topic and its relevance to contemporary issues. Briggs *et al.* (2006) show that small-scale horticulture can have effects that persist many hundreds of years after a landscape has been vacated by horticulturalists.

Because farmers often inhabit a site for many years, their sedentary lifestyle can also have an effect on local environments, as resources are used up faster than they can be replaced. Good archaeological studies of this phenomenon concern deforestation. Wood is required for construction and fuel, and this can result in reduction of forest cover, and changes to the species composition of forests. Such changes have been documented for horticultural societies, and these transformations will have a direct effect on local animal populations (Kohler and Mathews 1988; Lopinot and Woods 1993; Woods 2004).

We would therefore expect to find that farmers who hunt will do so in habitats that have been modified by their own cultivation methods and by the impact of sedentary human populations on local resources (Kohler 2004). By modifying the habitat, particularly the plant community, farmers also change the availability of potential prey/wild animals. As this regularly occurs in conjunction with hunting practices, we examine the effects of farming on wild animals below, in order to consider how these two phenomena contribute to the development of typical hunting practices.

The impact of hunting by sedentary farmers

Farmers who hunt have a direct impact on the local availability of prey. In this respect, they are not so different from hunter-gatherers or other predators, although they are, in contrast, often tied to a particular location, due to the need to tend fields or gardens. As a result, if game depletion occurs, they do not have the option of moving to a new location, but must modify their hunting practices in order to cope with the changing populations of animals.

Optimal foraging theory suggests, and various ethnographic studies have demonstrated, that hunters will typically make rational economic decisions to hunt animals that yield the greatest return for the smallest effort (Winterhalder 1981; Smith 1983; Lyman 2003). In many situations, hunting large mammals is the best choice for an optimal forager, and there are often further incentives, such as the ability for self-advancement through food sharing and through the prestige that comes from killing a large animal (Hawkes and Bliege Bird 2002; Kensinger 1989).

Grayson (2001) demonstrates that humans throughout the world have reduced the population densities of the most highly desired species. As population levels remain low in the face of continued predation, and because farming communities tend to be sedentary, large game should generally remain at low densities in areas inhabited by farmers (Vickers 1989). Furthermore, because farming typically supports higher human population densities than hunting and gathering, more pressure is likely to be placed on animal populations within environments occupied by farming societies.

The extensive literatures on this topic are mainly concerned with the discussion of the practice of hunting by horticulturalists who inhabit tropical forests (e.g. papers in Robinson and Bennett 2000). This topic is relevant to conservation of animal species in regions of the world where hunting of 'bushmeat' is seen as a threat to endangered species (e.g. Cowlishaw *et al.* 2005; de Vos 1978; Naughton-Treves *et al.* 2003; Robinson and Bennett 2004), and selective targeting of certain prey species may change important ecological relationships (Effiom *et al.* 2013). From an anthropological

perspective, Linares' (1976) definition of 'garden hunting' sparked interest in tropical hunting strategies, and there has been an ongoing debate about the impact of horticulture and hunting in tropical ecosystems.

In tropical forests, there is good evidence for reduced populations of large game, and a tendency for farmers to use a wider variety of small animal species once large game populations start to decline. Hames and Vickers (1982) demonstrated that hunters in Amazon villages prefer large game, but that as the population of large game declines, hunters are willing to take a wider variety of smaller game. According to Wadley *et al.* (1997), farmers in Indonesian forests rank large game species as the most preferred prey. Smith (2005) concludes that targeted hunting trips in Panama are usually directed towards larger species. Reviewing the 'bushmeat' trade in Africa, Cowlishaw *et al.* (2005) state that there is evidence for severe depletion of vulnerable species, which tend to be large and therefore highly desired. Such species are often relatively slow reproducers. Similar results are reported for Peru (Naughton-Treves *et al.* 2003).

Vickers (1982) cautioned that fluctuations in populations of large game in tropical forest might not be due to human hunting, and showed that random fluctuations in large game could cause apparent population declines in studies conducted over relatively short time spans. Fluctuations of game animals without human intervention are not only restricted to tropical forests. For example, an increase in game numbers during favourable times often creates conditions where natural predators increase in number. Often, this is followed by a relative sudden decline in the numbers of game animals as a result of intense natural predation (e.g. Mierau and Schmidt 1981). Game populations may be severely affected by factors such as weather, disease, vegetation changes, and poisonous plants (e.g. Allen 1980; Geist 1971; Sinclair 1977). Short-term natural fluctuations of game animal populations are impossible to document during prehistoric times, due to our inability to date samples precisely.

Even if some declines in large game populations are due to natural factors, there now seems to be sufficient evidence to suggest that farmers who hunt in tropical forests will deplete large game that are slow-reproducers. In addition to the evidence gathered from field studies, simulations support this proposition for both targeted hunting and untargeted trapping (Rowcliffe *et al.* 2003).

Garden hunting

As proposed by Linares (1976), farmers may adopt a strategy known as 'garden hunting'. In this system, small animals are attracted to gardens and to abandoned fields, because the productivity is high. Farmers hunt these species for many reasons:

1. they have depleted large game, so adding smaller game is an optimal strategy;
2. looking after crops makes it more difficult for them to schedule longer hunting trips to find larger game;
3. farming activities create local dense populations of small game;
4. small game reproduces rapidly, so there can be a high predation rate;
5. killing small game reduces the chance of crops being eaten by such pests.

In tropical forests, garden hunting provides farmers with a fairly stable, sustainable source of animal protein. Just as farmers exploit plants that are fast reproducers, so too in cultivate habitats they hunt animals with similar characteristics. Hunting of these small, 'weedy' animals has been documented in

many parts of the world. An early study by de Vos (1978) provides a summary of the smaller animals hunted in Africa. In the Amazon, Hames and Vickers (1982) showed that as large game declined, a diversity of small species was hunted. In Peru, Naughton-Treves *et al.* (2003) showed that even in forests that had been highly disturbed by farming, some small mammals, such as agoutis and armadillos, flourished in the fields and fallow areas. Wilkie (1989) documented snaring of animals in secondary forest areas in Zaire (now Democratic Republic of the Congo) by Lese horticulturalists. Smith (2005) demonstrated that farmers regularly hunt animals that would be major crop pests in Panama, and that a variety of hunting practices are employed. He suggests that garden hunting is not a substitute for more desirable kinds of hunting, but rather that it complements horticulture by removing pests and by keeping hunters closer to their settlements.

Studies of individual communities are supported by cross-cultural analyses. Redford and Robinson (1987) showed that different patterns of hunting could be documented in native and colonist communities in tropical South America, mainly because colonists tended to hunt animals that most resembled the familiar domesticates. Their study confirmed widespread hunting of small game in native communities, while variations in the game selected was due to the nature of the local environments, hunting technologies, cultural taboos and the intensity of gardening. Jerozolinski and Peres (2003) undertook a similar study, using a larger sample of native and colonist studies from South America. They also confirmed a general preference for larger prey species. They found that the average size of prey declined as a settlement aged, while the number of species exploited increased. Another extensive review was undertaken by Robinson and Bennett (2004), who included African and South American case studies. They found that animal biomass, potential sustainable off-take of animals, and actual off-takes, varied in a complex way with rainfall, such that dry forests and mesic grasslands had the highest productivity, and wet forests and xeric grasslands were less productive. They argued that horticultural lands and secondary forests would often possess greater potential for animal protein than untouched forests.

The archaeology of garden hunting

The garden hunting model was developed for tropical environments, where such hunting is still common. Temperate regions present a somewhat different situation. Firstly, most temperate farmers also keep domestic animals, so it is difficult to find examples of recent temperate farming communities where hunting supplied most of the animal protein. Secondly, farming societies in temperate areas that lacked domestic animals, notably in eastern North America, were affected by the actions of early European colonists, who transformed the environment and eradicated many indigenous communities. As a result, we have few ethnographic or historic records of such communities. Therefore, in the following sections, we rely more on archaeological data.

Neusius (1996) argued that in the semi-arid American Southwest, where maize horticulture was important, garden hunting would be a logical strategy. She demonstrated that garden species (mainly rodents and lagomorphs) made up a substantial proportion of most animal bone assemblages in prehistoric sites dating to the late first millennium AD in south-west Colorado, and that large mammals, likely to have been highly sought after, were generally absent from the assemblages. The only exception to this pattern was deer, which are known to raid gardens and to inhabit disturbed habitats. Working in the same general area, Driver and Badenhorst (Driver 2002; Badenhorst and Driver 2009) demonstrated a general decline in the use of deer between c. AD 600–1300, and an increase in the use of cottontail rabbit, when compared to the larger jackrabbit. This suggests that garden hunting intensified over time, although the situation is complicated by the introduction of domestic turkey as a

food item during the period studied.

Similar results have been achieved in other areas of the American South-west (James 2004), and there seems to be good evidence that large game was often depleted by maize horticulturalists in that region. James argues that along major river systems, fishing may have become more important, and even documents a reduction of fish size through time in southern Arizona, suggesting that intensified fishing may have been responsible. Dean (2005), also working in southern Arizona, has shown that as agriculture intensified, the mix of rodent species changed and the quantity of rodents likely to have been attracted to anthropogenic environments also increased, suggesting that garden hunting occurred. In general, archaeological studies in the American South-west support the resource depletion/garden hunting model derived from tropical environments.

However, a different picture emerges when we consider the hunting practices of horticulturalists in eastern North America. At the time of European contact, indigenous groups living in, and east of, the Mississippi Valley from the Great Lakes to the Gulf of Mexico relied upon a mixture of horticulture, gathering, hunting and fishing for their subsistence (Schroeder 2004). It is not clear, however, how long intensive horticulture had been practiced. Palaeo-ethnobotanists have documented the domestication, cultivation and storage of a variety of indigenous plants, thousands of years before the introduction of maize, but it is unclear whether communities in the Eastern Woodlands were dependent on horticulture until the intensification of maize production, c. AD 1000 (Schroeder 2004).

The 'Late Woodland' horticulturalists that inhabited the region immediately prior to the intensification of maize production did not have a severe impact on the most important large mammal in the region, the white-tailed deer. It also appears that the maize horticulturalists of the succeeding Mississippian cultures did not deplete deer populations in the same way that contemporaneous maize horticulturalists were doing in the American South-west. For example, VanDerWarker (2001) reviewed data on six sites dating to AD 1000–1450 from Virginia and North Carolina. Even though a wide range of taxa were recovered, deer was dominant in mammalian assemblages, suggesting that hunting was not sufficiently intense to result in the local resource depression of large game. Similar results can be seen for approximately the same time period in the Tombigbee Valley to the south (Jackson and Scott 2002), or in the Midwest region (Styles 2000).

There are a number of possible reasons for the apparent maintenance of large mammal populations. First, not all Late Woodland sites were necessarily occupied by intensive horticulturalists, and it is possible that Late Woodland people were more mobile, less dependent on farming, and living at lower local population densities than inhabitants of the American South-west. Second, carefully collected assemblages show that fish and other aquatic resources (especially freshwater turtles) were used in large quantities; as a result there may have been less pressure on deer populations. Third, it is possible that farming activity was confined to certain kinds of locations, and that large areas of land were not disturbed; if so, seasonal hunting camps for deer may have been established (e.g. Purdue *et al.* 1989). Even in Mississippian period sites, where human population densities were probably higher, and maize horticulture was probably more intense, deer dominates mammalian assemblages (e.g. Zeder and Arter 1996), and aquatic resources may have relieved deer populations from some hunting pressure. Fourth, given the reproductive potential of deer, and the mosaic of preferred feeding and refuge patches in the pre-European landscape, it may have been virtually impossible to inflict serious pressure on deer (Smith 2009).

Another example from North America shows how resource depression might be avoided due to a combination of prey mobility and human scheduling decisions. Ethnographic and ethnohistoric studies of village horticulturalists (such as Mandan, Hidatsa and Arikara) provide an account of life along the Missouri River during the contact period with Europeans. These villagers subsisted on a

combination of garden produce and large game, notably bison. Bison hunts coincided with bison migrations that brought the herds close to villages in the fall and winter (Meyer 1977). Seasonal hunting was not intense enough to cause significant population reductions in bison, yet still acquired enough meat to be stored for consumption over the rest of the year. As a result, even though pests were attracted to gardens, they were mainly hunted by young boys (Weitzner 1979), and the total consumption of such species seems to have been low.

Another situation in which hunting of large game might be maintained is when settlement patterns change from dispersed to aggregated. Speth and Scott (1989) examined this in the context of the American South-west, where cycles of community aggregation and dispersal are well documented. They argue that in aggregated farming communities, hunters must make longer and longer journeys to obtain animal protein, due to local depletion of game species near the villages. Foraging theory suggests that as travel time increases, an optimal strategy is to hunt animals with the largest body size. Speth and Scott also argue that a stable base of plant foods gave hunters the security to make relatively risky long-distance trips in search of larger animals. They document a number of cases where aggregation of human settlement seems to lead to an increased use of large game. An alternative hypothesis is that communities in which large game hunting persisted were near an uninhabited hinterland, that either served as a hunting area or as an under-exploited source area (Schollmeyer and Driver 2013).

However, Dean (2001) has suggested that such cases may result more from the emergence of new forms of social organisation in aggregated communities, leading to a greater emphasis on feasting. She documents intra-site variation in the distribution of large mammal bones, with communal areas (e.g. plazas) having the highest ratios of large to small mammals. Similar results have been obtained by Potter (1997) and Muir and Driver (2002). As the above discussion shows, there are well documented examples in which horticulturalism does not result in large game depletion. Regardless of the cause(s) of this, it is apparent that the predicted resource depression/garden hunting model will not apply in every case.

Resource depression and garden hunting: conclusions

As discussed above, we would expect to see people influencing animal populations through hunting and manipulation of the environment. Farming communities that lack domestic animals typically (but not always) depress large game populations, resulting in a greatly expanded diet breadth, achieved by hunting or trapping small game which possess high reproductive rates. Often such species are tolerant of humans, and thrive in disturbed habitats created by farming. In addition, some small species may be attracted to crops. We would expect to find this occurring under the following circumstances:

- (a) human population was sufficiently dense to impact large game numbers;
- (b) neither humans nor their smaller prey were highly mobile;
- (c) farming practices created environments in which small animal populations could increase;
- (d) long-range hunting of large game was not efficient.

The horticultural/hunting societies of the American South-west show that this model can be extended outside the tropics to temperate areas. On the other hand, we can document situations in which farmers would not deplete large game resources and would therefore be less likely to rely on garden hunting practices. Examples from the North American Eastern Woodlands and the Missouri valley show that

large game was not depleted by the presence of horticultural societies, and accompanying faunal assemblages demonstrate that garden hunting may have been a supplement to other forms of prey acquisition (deer hunting and fishing), but never a dominant practice. Even within the American South-west, where garden hunting seems to be common, exceptions occur and large game hunting persists. The reasons for these exceptions probably vary from one place to another, but some important factors include the following:

- i. large game was only seasonally available;
- ii. large game was so abundant that farmers could not reduce population levels significantly;
- iii. there was a large hinterland in which game could seek refuge from human predation;
- iv. human settlements and population were not dense enough for hunters to have an impact on large game populations;
- v. aquatic resources provided an alternative source of animal foods, thus reducing hunting pressure on large terrestrial game;
- vi. social rewards for acquiring large game were so great that some hunters continued to hunt large animals, even when this did not make sense from an optimal diet perspective.

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Evaluating seasonality of birth in gazelles in the Middle Euphrates Valley: confirming ethological assumptions in the Abu Hureyra model

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Introduction

Tony Legge, Abu Hureyra, and gazelles

Gazelles were a focus of interest in Tony Legge's research, from his first work on Natufian settlements to his life-long research project at Abu Hureyra, in collaboration with Peter Rowley-Conwy (Legge 1972; 1975; 1977; Legge and Rowley-Conwy 1987a; 1987b; 2000). His research in this field fascinates new generations of younger zooarchaeologists and archaeologists working in the Near East and surrounding areas. Indeed, gazelle exploitation during prehistoric times in the Near East continues to be a research focus for several teams and institutions, currently developing new projects and scientific contributions to our understanding of the nature of human–gazelle relations (Davis 1983; Lieberman *et al.* 1990; Cope 1991; Helmer 2000; Martin 2000; Gourichon 2004; Tornero 2006; Munro *et al.* 2009; 2011; Bar-Oz *et al.* 2011).

At Abu Hureyra, Tony Legge had the opportunity to go deep into questions related to gazelle exploitation (Legge and Rowley-Conwy 1987a; 1987b; 2000; Legge 1975; 1977). Abu Hureyra is in the Middle Euphrates Valley in Syria, one of the most important areas for the study of the first agrarian societies. The data from Abu Hureyra, along with all contemporaneous sites in this region such as tell Mureybet, Jerf el-Ahmar, D'jadé, Tell Halula and Cheik Hassan, provide our main understanding of the transition from hunter-gatherer to farming communities in the northern Levant. Gazelles played an important role in animal exploitation strategies in Abu Hureyra mainly during Natufian levels (~11000–9500 cal BC), where this resource dominates faunal assemblages (>80%), but also during PPNB occupations (7600 cal BC) when its proportion decreased. A first contribution from Tony Legge to gazelle research in Near East was the visualization and conceptualization of its exploitation at a seasonal scale (Gourichon, 2004, 402). A second important advancement was to open the debate over the use of specific systems to hunt this resource, driving whole herds into kite structures. Indeed, Legge and Rowley-Conwy (1987a; 1987b; 2000) proposed a model where gazelles could only be exploited during specific seasons, according to their availability near Abu Hureyra: only in spring and early summer, during its northern seasonal migrations to the Middle Euphrates Valley from southern locations in northern Transjordan. The model was constructed using age of death based on eruption and wear stages of gazelle tooth remains, but also with modern data on gazelle ethology and data from historical

reports of early travellers (from the seventeenth to nineteenth centuries), which described and reported gazelle sightings and seasonal movements. One of the key aspects of this model is the season and seasonality of gazelle births. This data is used to infer seasonality and season of kill events after the estimation of the age of death (Legge and Rowley-Conwy 1987; 2000). The Abu Hureyra model assumed a very restricted seasonality of birth, and a season of birth in spring (from March to early April), using information from modern gazelle ethology. However, information about seasonal reproduction patterns had been never demonstrated from direct fossil fauna.

Ethological studies show that seasonality of birth in the genus *Gazella* is very variable. Some species breed annually with very timed births, while others breed twice and sometimes throughout the year, like mountain (*Gazella gazelle*) or dorcas gazelle (*Gazella dorcas*) in the Near East (Baharav 1983; Habibi 1991; Dunham 1997). There are no studies focused on goitered gazelle (*Gazella subgutturosa*) in the Near East, with the closest references coming from Turkmenistan, Kazakhstan and Uzbekistan. These studies usually describe synchronised annual breeds (where twins are very common) and periods of birth restricted in time. Birth coincides with periods when food is more abundant (i.e. better quality pastures) and when there are favourable climatic conditions in areas with poor vegetal resources (semi-deserts and steppes), which occurs in spring when moisture and temperatures combine to produce new plant growth (Gorelov 1972; Blank 1998; Zhevnerov 1984; Pereladova *et al.* 1998). In these studies season of birth takes place between mid April and early May (May, in Zhevnerov *et al.* 1984; mid-May, in Blank 1998; mid-April, in Pereladova *et al.* 1998), and some authors observed a very restricted length of birth period (4–5 days in Blank 1998). However, all of these references represent locations in northern latitudes (~45°N), unlike the Middle Euphrates Valley (~34°N), and it is well known that the photoperiod more strongly regulates and adjusts stronger sexual cycles in animals that exhibit estrous and anestrus seasons like gazelles. For example, the sand gazelle (a close sub-species of goitred gazelle) living in Saudi Arabia (25°N) is able to produce a second birth period during the year when good body conditions exist as a consequence of a longer estrous season, resulting from a less pronounced inhibitory action (or simply no action) of the long photoperiod in this latitude (Sempéré *et al.* 2001). Furthermore, some of the previously cited references describe populations in protected or enclosed contexts, where mobility, diet and social structures are partly modified by artificial conditions or stress generated by human contact. Thus we cannot assume that they represent truly wild conditions. Finally, all of these reproduction behavioural patterns are strongly influenced by the group's adaptations to its specific ecological situations (Baharav 1983; Martin 2000), and potential variability should be considered when we apply this information to the past.

Alternatively, seasonal reproduction patterns can be tracked directly from sequential analysis of oxygen isotope values along the tooth crown of hypsodont fossil species. This approach uses the short-term seasonal variation of climatic signal to reconstruct season and seasonality of birth. This approach has been applied successfully in different species, including sheep (Balasse *et al.* 2003; 2006; Tornero *et al.* 2013), cattle (Balasse and Tresset 2007; Tornero and Saña 2010; Balasse *et al.* 2012b) and goat (Tornero 2011), but has not been applied to the genus *Gazella*. Kohn *et al.* (1998) tested method guidelines of sequential analyses with a sample of Grant's gazelle. They sequentially analysed the M1, M2 and M3 of a single individual and measured $\delta^{18}\text{O}$ values. Results show large changes (>2–3‰) in intra-tooth compositions following a continued oscillation of values through all molars, more sharply in M2 and M3 molars. These data suggest that the application could be a success in *Gazella*, although important limitations exist. For example, the period of tooth crown formation (both in M2 and M3) is not well known. The timing of initial enamel mineralisation relative to eruption is also not known, nor is the duration of the mineralization period. That means that it is difficult to accurately estimate the length of the period that is potentially represented from sequential series in tooth molars as

well as to link these changes in isotopic sequences to a specific period in the life of the animal. Comparability among individuals is also uncertain because inter-individual variability of timing of enamel growth rate is completely unknown. Furthermore, species-specific differences between gazelles are unknown at this level.

Objectives

The main objective of this work is to evaluate the seasonality of birth in a sample of goitred gazelle (*Gazella subgutturosa*) from Tell Halula (Middle Euphrates Valley, Arab Republic of Syria), a settlement very close to Abu Hureyra (<80 km) and with contemporaneous occupations (Middle and Late PPNB). Our aim is to test the hypothesis of a restricted seasonality of birth or synchronised seasonality of birth for this species during this period.

Considering the absence of isotopic analyses for gazelle, a great part of this work should be conceived as an evaluation of the strength and reproducibility of the methodology when applied to gazelle remains. We selected paired second and third molars to test how sequences can be retrieved for the seasonal interpretation of $\delta^{18}\text{O}$ sequences. More specifically, we aim to define the length of the period represented in each M2 and M3, and evaluate the potential inter-individual variability in the timing of enamel growth. A definition of these methodological aspects is needed as a basis in order to advance the application of this approach in gazelles, as well as to broaden the questions related to the seasonal exploitation of gazelles in this area.

Materials and methods

Tell Halula

Tell Halula is a large archaeological site in the Middle Euphrates Valley some 800 m from the right bank of the Euphrates (Fig. 21.1). Archaeological work involved the excavation of 4200 m², documenting a practically continuous occupation for over 2000 years, with a complex stratigraphic sequence extending from 7800 to 5700 cal BC, Middle PPNB to Late Halaf (Molist 1996; 2013). From the start, the occupation represents a sedentary way of life. During Middle and Late PPNB levels the settlement was organised around dwelling units that all showed the same layout. They are multicellular mudbrick houses with a rectangular floor plan (Molist 1998; Saña and Molist 2004; Molist *et al.* 2007). Subsistence strategies were mainly based on agriculture and livestock: domestic cereal production is well documented (naked wheat, barley and emmer cultivation) while animal husbandry is focused on cattle, goat, sheep and pig (Araus *et al.* 2014; Buxó and Rovira 2013; Saña 1999; Tornero 2011). However, the community exploited other resources. Charcoal studies revealed the exploitation of species from a wide range of ecosystems: river valley (*Tamarix*, Salicaceae, *Ulmus* and *Fraxinus*), oak forest (*Quercus* sp., Pomoideae and *Ficus carica*), and steppe (*Amygdalus*) (Willcox and Català 1996; Piqué and Mensua 2008).

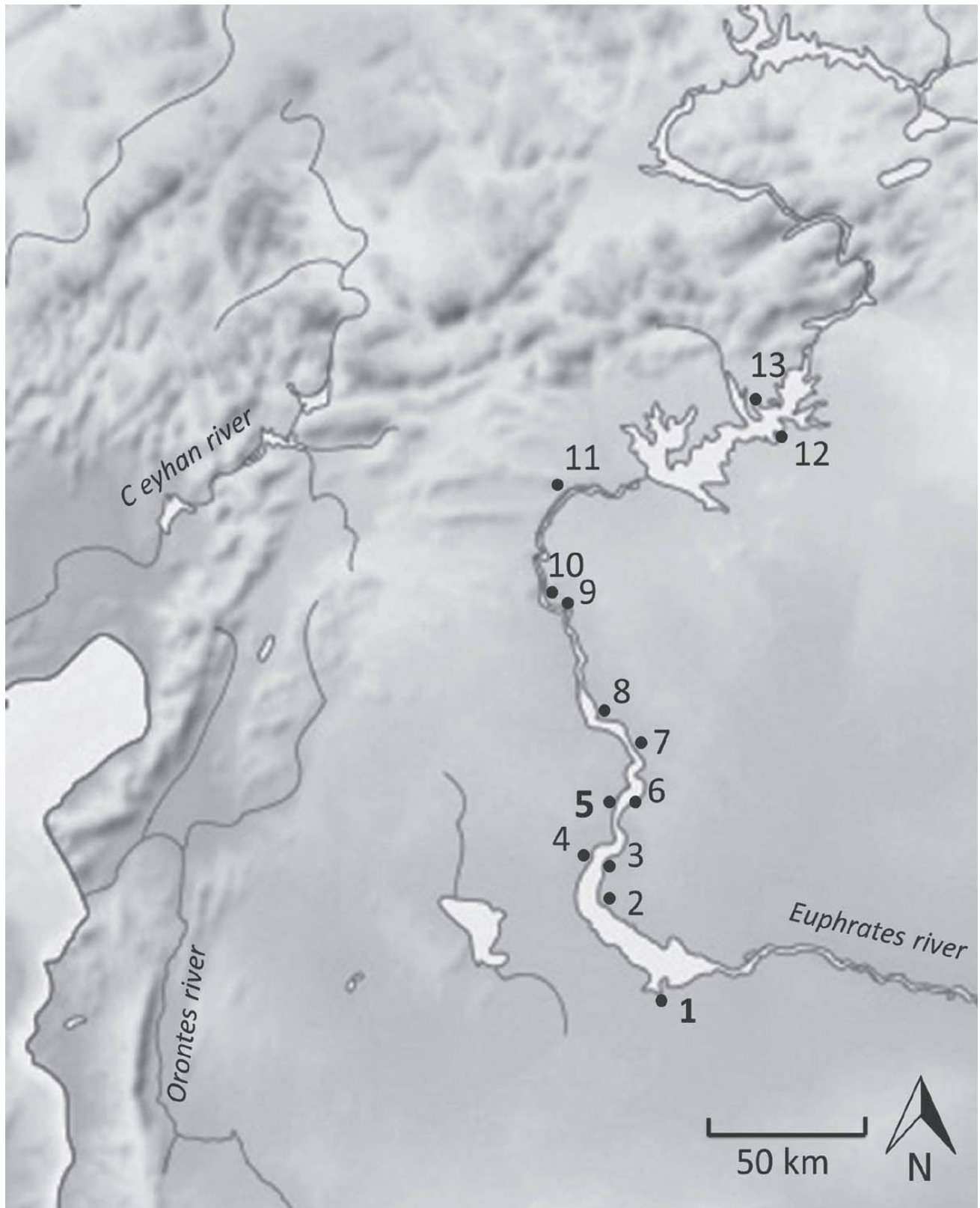


Fig. 21.1. Map distribution of the archaeological sites mentioned in the text: 1. Abu Hureyra; 2. Tell Mureybet; 3. Cheikh Hassan; 4. Narh el-Hom r; 5. Tell Halula; 6. Jerf el-Ahmar; 7. Dja'de el Mughara; 8. Tell 'Abr; 9. Akarçay tepe; 10. Mezraa Teleilat; 11. Hayaz Höyük; 12. Nevali Çori; 13. Gritille.

Zooarchaeological data shows that the exploitation of wild species also occurred. Different species were hunted, representing diversified ecosystems: *Cervus elaphus*, *Dama mesopotamica*,

Gazella subgutturosa, *Equus hemionus* and *Lepus capensis*. Red deer and fallow deer are species linked to forest and scrub areas rich in water, which could be present only in the deciduous forests along the Euphrates riverbanks. Goitred or Persian gazelle, onager and hare are species linked to the more dry and depleted environments of the steppe, which is dominant in the area and is more exposed to seasonal changes. The representation of these species through the Tell Halula sequence shows a high representation of the humid species during the early phases of the site, while they become very rare after 7000 cal BC. By contrast, the steppe species show a constant representation all through the sequence, although they decline at the end (Saña 1999; Tornero 2011). Results from previous $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ analysis of bulk enamel samples of gazelles showed better environmental conditions than today in terms of volume of mean annual precipitation and mean annual temperature between 7800 and 7000 cal BC, while documenting the existence of a C_3 -grass environment, which was probably dominant in the steppe (Tornero 2006; Saña and Tornero 2008).

Materials and methods

Five right mandibles of *Gazella subgutturosa* were selected for analysis (HL GZ 01, HL GZ 01, HL GZ 02, HL GZ 03, HL GZ 05 and HL GZ 06). All were recovered from Late PPNB levels and stratigraphic units and features described as rubbish areas and paleo-soils linked to dwellings units. The mandibles all contain permanent dentition, with third molars in eruption or in early stages of wear. Studies of modern *Gazella gazella* show that the second molar erupts at 6–7 months, with wear present in both lobes at 7–11 months. In third molars eruption takes place at the end of the first year and wear begins at 13–16 months (Davis 1980; the range of eruption times reflect natural variability among individuals). Legge found no appreciable differences in timing of eruption and wear stages from Davis's study in a collection of *Gazella gazella* and *Gazella dorcas* from the Department of Zoology at the University of Tel Aviv and the collection of *Gazella subgutturosa* that he studied from the Badyhyz Reserve in Turkmenia in the Lomonsov Museum of Zoology at the University of Moscow (Legge and Rowley-Conwy 2000, 436). In our sample, wear is present in M2 while it is just beginning in M3. We can therefore assume that all our individuals reached an estimated age of death of at least 1.5 years.

We sampled M2 and M3 from each individual (Fig. 21.2). Sampling and treatment protocols of enamel samples have already been published (Balasse *et al.* 2002; Tornero *et al.* 2013). Sequential sampling was performed on the buccal side of the teeth perpendicular to the tooth growth axis, from the crown apex to the enamel root junction (ERJ). In M2 sampling was performed on the anterior lobe, in M3 on the middle lobe. For M2s, 8–12 enamel samples were drilled out, while for M3s it was 13–17 samples. The total number of samples was 117.



Fig. 21.2. A sampled second and third molar (specimen HL GZ 01).

Enamel powder samples weighed 4–6 mg. Powder samples were then chemically treated for 4 hours in 0.1M acid acetic (0.1 ml solution/mg of powder sample), rinsed several times with distilled water and freeze-dried. Analyses of $\delta^{18}\text{O}$ values were performed on enamel bioapatite carbonate. Samples weighing $\sim 600\ \mu\text{g}$ were analysed on a Kiel IV device interfaced to a DeltaV Advantage IRMS. Samples were reacted under vacuum with orthophosphoric acid at 70°C in individual vessels. Five analytical series were conducted to analyse all the samples. Accuracy and precision of the measurements were checked using an internal laboratory calcium carbonate standard (Marbre LM normalised to the international standard NBS 19) ($n=36$; 6–8 in each analytical series). Final results are expressed in V-PDB.

Results

Oxygen isotope results

Table 21.1 summaries the $\delta^{18}\text{O}$ values. Sequential oxygen data is given in Table 21.2. Mean $\delta^{18}\text{O}$ results vary from 0.7‰ to -2.4‰ within each tooth for M2s, and from 0.8‰ to -0.8‰ for M3s. Max-Min values range from 1.1‰ to 5.3‰ in M2s and from 4.9‰ to 9.7‰ in M3s.

Sequential $\delta^{18}\text{O}$ series

Sequences of $\delta^{18}\text{O}$ values for each individual and molar are presented in Figure 21.3. All sequences

show variation in oxygen isotopic values. This variation follows an undulating pattern close to a sinusoidal variation in M3 sequences, where highest and lowest distribution of oxygen peaks are distributed regularly throughout the sequence. These peaks represent warmer and colder seasonal events in a year (Fricke and O'Neil 1996).

The length of the period represented in these sequences is different in M2 and M3. In M2 it is shorter than in M3. In M2 it is difficult to estimate accurately, but some specimens show a period of 0.25 year, three months of a seasonal cycle. In M3 all sequences show at least periods of 0.5 year or more than 6 months.

Table 21.1. Summarised $\delta^{18}\text{O}_{V-PDB}\%$ data for each analyzed specimen by tooth position

<i>M2</i>					<i>M3</i>			
$\delta^{18}\text{O}_{V-PDB}$					$\delta^{18}\text{O}_{V-PDB}$			
	<i>n</i>	<i>mean</i>	<i>max.</i>	<i>min.</i>	<i>n</i>	<i>mean</i>	<i>max.</i>	<i>min.</i>
HL GZ 01	12	−0.7	2.3	−3.0	17	0.8	6.7	−3.0
HL GZ 02	8	−2.4	−0.1	−4.3	13	0.5	4.7	−4.3
HL GZ 03	9	0.5	1.0	−0.5	13	−0.8	2.1	−2.8
HL GZ 05	10	−1.3	0.5	−2.9	14	−0.8	3.4	−2.8
HL GZ 06	8	0.7	1.3	0.1	13	0.7	3.4	−1.8

Discussion

Seasonality of birth

Seasonality of birth is evaluated from the sequential series. Positions of maximum and minimum events in M3 sequences are compared. In all specimens maximum positions occur between 0 and 5 mm while minimum values occur between 12.5 mm and 17.5 mm. These results suggest a restricted period of seasonality of birth or a seasonally synchronized period of birth for all specimens. The length of the birth season cannot be estimated from our data but a reduced season of birth is expected. This similar seasonality of birth fits well with available ethological data for Persian gazelle (Gorelov 1972; Blank, 1998; Zhevnerov 1984; Pereladova *et al.* 1998; Sempéréé *et al.* 2001).

Inter-individual variability in timing of enamel growth period

The analysis of M2s and M3s from the same individuals allows inter-individual variability in the timing of enamel growth period to be observed. Data presented here suggest that this variation is very low in the analysed specimens. Last values on M2 sequences fit well both in absolute values and trend with first values recorded in M3 for all cases.

Although statistically larger sample sizes would be desirable, this variation is low. More variable

timing in enamel formation in M3 than M2 has been observed in sheep, both modern (Blaise and Balasse 2010) and archaeological (Tornero *et al.* 2013). We suggest that because of its faster dental development (crown formation in less than 6 months in M2 and 12 months in M3) this variation should be reduced.

Conclusion

This study shows that sequential analyses can be well integrated into research on gazelle. Although dental development is fast, variation in $\delta^{18}\text{O}$ values throughout tooth enamel crowns can be well tracked from M2s and M3s. However, some observations are relevant for future studies:

- Because enamel formation is very fast in gazelle, sequences cover short periods (~3 months in M2 and >6 months in M3). This means that it is not possible to infer seasonality of birth from M2 sequences because no maximum or minimum event could be regularly represented. Sequences in M3s with clear sinusoidal variations allow recognition of, at least, one maximum or one minimum event. However, reliable quantitative estimations of the length of the birth period using mathematical models require at least one maximum and one minimum event (Balasse *et al.* 2012a). Therefore, these estimations could be problematic in sequences with only one registered seasonal event.
- However, analyses of M2 and M3 sequences from the same specimen show a period of nearly a year. Furthermore, considering the low inter-individual variability in timing of enamel tooth growth, this should be the best option for the integration of sequential analyses in gazelle remains. Moreover, a combination of M2 and M3 sequences is suggested if reliable readings are to be obtained, although this should involve a correction of the differences in enamel growth rate.

Table 21.2. Results of sequential analyses of $\delta^{18}\text{O}_{V-PDB}\text{‰}$ results for each M2 and M3 of each specimen (GZ 1–6)

GZ 01		GZ 02		GZ 03		GZ 05		GZ 06	
M2		M2		M2		M2		M2	
mm	$\delta^{18}\text{O}_{\text{V-PDB}}$	mm	$\delta^{18}\text{O}_{\text{V-PDB}}$	mm	$\delta^{18}\text{O}_{\text{V-PDB}}$	mm	$\delta^{18}\text{O}_{\text{V-PDB}}$	mm	$\delta^{18}\text{O}_{\text{V-PDB}}$
17.98	2.3	11.81	-0.1	10.62	0.7	13.01	0.5	11.71	0.1
16.34	1.6	10.65	-1.1	9.52	1.0	11.98	0.4	10.3	0.2
15.11	1.0	9.44	-1.4	8.25	1.0	10.64	-0.2	9.35	0.6
13.81	0.3	7.89	-2.2	7.38	1.0	9.71	-0.6	8.0	0.8
12.21	-0.1	6.18	-2.8	6.39	0.6	8.25	-1.2	6.46	0.8
10.68	-0.7	5.84	-3.6	4.84	-0.5	7.34	-1.7	5.21	1.2
9.67	-1.0	4.49	-3.6	3.58	-0.2	6.33	-2.0	4.05	1.3
8.33	-1.4	3.26	-4.3	2.34	-1.0	5.28	-2.4	2.87	0.6
6.68	-2.0			1.71	-1.1	4.33	-2.5		
5.46	-2.5					2.98	-2.9		
4.2	-2.8								
2.95	-3.0								

M3		M3		M3		M3		M3	
mm	$\delta^{18}\text{O}_{\text{V-PDB}}$	mm	$\delta^{18}\text{O}_{\text{V-PDB}}$	mm	$\delta^{18}\text{O}_{\text{V-PDB}}$	mm	$\delta^{18}\text{O}_{\text{V-PDB}}$	mm	$\delta^{18}\text{O}_{\text{V-PDB}}$
21.46	-3.0	18.57	-4.3	15.35	-2.2	18.4	-2.6	16.16	-0.4
20.12	-2.9	17.39	-4.1	14.4	-2.3	16.71	-2.8	14.14	-1.3
19.24	-2.6	15.91	-3.6	13.22	-2.7	15.94	-2.7	13.3	-1.5
18.19	-2.6	14.67	-2.6	12.16	-2.8	14.83	-2.5	12.23	-1.8
17.35	-2.2	13.35	-1.9	10.86	-2.3	13.73	-2.0	10.88	-1.2
16.33	-1.7	11.77	-0.4	9.76	-1.5	12.57	-1.5	9.55	-0.7
15.23	-1.4	10.59	0.7	8.85	-0.8	10.79	-0.6	8.45	0.7
14.14	-1.2	9.19	1.8	7.64	-0.5	9.38	-0.2	7.02	1.6
12.71	-0.2	8.05	3.4	6.44	0.6	8.21	0.6	6.21	2.0
11.49	0.6	6.36	4.3	5.54	1.7	7.12	1.0	5.04	2.6
10.48	2.3	5.58	4.7	3.98	1.7	5.65	2.3	3.71	2.1
9.06	2.4	4.22	4.3	2.43	2.1	4.29	2.9	2.68	3.4
7.86	3.4	2.71	3.9	1.52	2.3	2.74	3.3	1.56	3.3
6.55	4.3					1.53	3.4		
5.38	5.9								
4.04	6.7								
2.56	5.4								

Furthermore, this study shows for the first time in fossil populations that goitred gazelles exploited by the last hunter-gatherers and first farmers in the Near East had a restricted birth season. Synchronized seasonality of birth was probably an adaption to environmental constraints on gazelles inhabiting the Middle Euphrates Valley. Although photoperiod can cause physiological changes in ovarian capacity, our results suggest that gazelles from the Middle Euphrates Valley had a similar synchronised birth season as modern comparatives from northern locations (Turkmenistan, Kazakhstan and Uzbekistan). This synchronised seasonality of birth confirms the assumptions that Tony Legge used to construct his model, as well as those of others dealing with seasonal gazelle exploitation in the area (Gourichon 2004). The seasonality of cull found by Tony Legge at Abu Hureyra (Legge and Rowley-Conwy 2000) is now confirmed, because our data suggest no differences in seasonality of birth and very little variability in timing of tooth crown formation. Finally, this data is very useful for interpreting gazelle exploitation at Tell Halula from its demographic profiles, and also for evaluating the magnitude of the

innovations involved in the management of early domestic animals at this settlement. All information about gazelle reproduction patterns could be useful as a baseline from which to compare with conserved or manipulated rhythms and dynamics in the first domestic species.

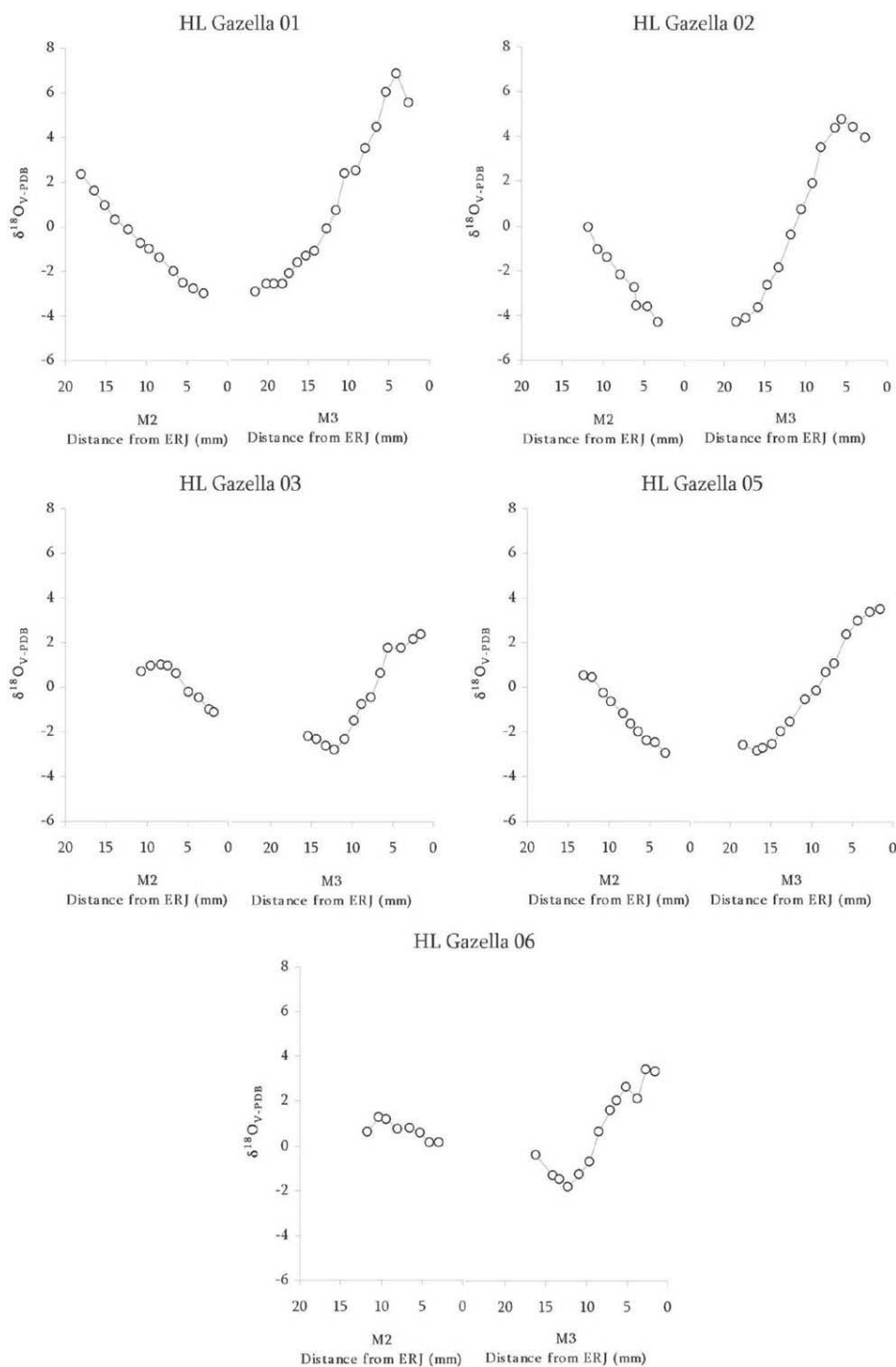


Fig. 21.3. Sequential results of $\delta^{18}\text{O}$ values for each tooth and individual.

This is not the end of our study, but a first necessary step. This is the first work integrating sequential isotopic analysis to seasonal exploitation patterns of goitred gazelles during the transition from hunter-gatherers to farmers in the Near East. Our study will continue as a part of a project focused on the evaluation of the degree of seasonal mobility of gazelles hunted in the Middle Euphrates

Valley.

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Hunting and herding in the Middle Neolithic of central Serbia: a zooarchaeological analysis of Stragari-Šljivik, Serbia

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Introduction

Many years ago, Tony Legge conducted the analysis of the Middle and Late Neolithic fauna from the archaeological site at Selevac, Serbia that was being excavated by Ruth Tringham and Dušan Krstić (Tringham *et al.* 1980; Hanson and Cain 2007). At that time (1977), I was a lowly MA student completing my thesis while participating in H. Arthur Bankoff's project slightly to the south in Smederevska Palanka (Bankoff *et al.* 1980; 1988). As the results of Tony's faunal analysis at Selevac began to percolate outwards into the small community of western archaeologists working in old Yugoslavia, I began to be intrigued by the possibilities offered by fauna to answer the questions posed by Andrew Sherratt (Sherratt 1981) about the nature of the Neolithic to Bronze Age transition. I had never thought of faunal analysis as a specialty up to that point. I had always planned on working in the Near East in order to pursue my interest in settlement patterns, human osteology, mortuary analysis and their implications for understanding the hierarchical development of early complex societies. However, the Iranian Revolution and the Iran-Iraq War intervened and sent me scurrying for a new subject for my looming PhD thesis. As I returned to the Balkans in 1980, my experience with human osteology was seen as a bonus, but not in the way that I had envisioned. Most archaeologists of the time did not understand that there are different types of bones and that human osteology is not the same as faunal analysis. Unfortunately, this attitude continues to prevail particularly among archaeologists concerned with classical and later periods (e.g. Magness 2012, 7).

My early zooarchaeological analyses in the central Balkans focused on aspects of Andrew Sherratt's Secondary Products Revolution model explaining how and why cultures evolved in a particular trajectory from the Neolithic to the Bronze Age, but I lacked many of the intellectual tools to undertake this analysis at the time. In 1981, on a trip to London to explore my PhD thesis topic, I had the glorious opportunity to meet Tony for the first time. In fact, we met in Cambridge where he brought me on a tour of the faunal lab established by Eric Higgs and introduced me to a number of what would become future colleagues (as well as introducing me to the beauty of English pub life at the *Eagle*). He had just completed his Grimes Graves analysis and was applying Sebastian Payne's domestic animal exploitation models (Payne 1973) to explain the patterns in the data (Legge 1981). This analysis and Tony's analytical perspectives provided me with the means to test Sherratt's models with my newly

collected Serbian data.

During our initial (and not only) day together, Tony kept pestering me to investigate whether the patterns I was uncovering began before the end of the Neolithic. John Nandris, whom I had briefly met earlier at UCL, made similar recommendations although he wished me to focus on the Early Neolithic. They were certain that the patterns of the later Neolithic were not the same during the Middle and Early Neolithic, but such data from the region were unavailable to me at that time. Upon completion of my PhD thesis (Greenfield 1985), I finally had the opportunity to pursue their suggestions when the late Svetozar Stanković (University of Belgrade) gave me the opportunity to analyse the fauna from his new excavations at the Early and Middle Neolithic site of Stragari-Šljivik in central Serbia (hereafter referred to as Stragari). I spent parts of the next three summers analysing the remains and visiting the ongoing excavations. In fact, this experience led to my involvement in the excavations at Blagotin, which I codirected for a few years in the early 1990s (Stanković and Greenfield 1992; Greenfield 2000; Greenfield and Jongsma-Greenfield 2014).

In the early 1990s, Svetozar and I worked on sorting out the chronology of the deposits from Stragari. In the midst of writing up the results, the Balkan wars began and Svetozar passed away prematurely (from a life of hard living and inability to obtain medication during the UN embargo of Serbia). One delay led to another before I was finally able to return and focus on the subject. In this paper, I present some of the results of my research at the site for the first time.

My initial results from the analysis surprised me so much that I did not know what to make of them at the time. Instead of the heavily domesticated economies that I was accustomed to seeing from the end of the Neolithic onwards, Stragari presented a much more complex picture of hunting and herding. The results presented here may have profound implications for our understanding of Middle–Late Neolithic (Vinča) economies in the region. This paper is dedicated to the memory of Tony and Svetozar, without whom it would never have happened.

The site

Region

The archaeological site of Šljivik is located at the downstream edge of the modern village of Stragari. It is nestled in a small stream valley within the central Serbian region of Šumadija (Arnold and Greenfield 2006, 45), approximately 200 km south of Belgrade (Fig. 22.1). The site is on the left bank of the Riljačka stream, a tributary of the Western Morava River about 7 km from their junction (Stanković 1988b, 95; 1988c; 1989; Arnold and Greenfield 2006, 45, 62). Located at an elevation of *c.* 179 m ASL (Google Earth), within the floodplain of a broad stream valley into which the modern stream is deeply incised (Arnold and Greenfield 2006, 62), the site nestles amidst rolling hills surrounded by higher mountains, interspersed by narrow upstream and broad downstream valleys.

The region is characterised by a temperate continental climate with dramatic microclimatic variation depending upon local geography. The zone features year-round precipitation, deciduous vegetation adapted to high levels of moisture, and thick forests. These create excellent conditions for agricultural soil development, as evidenced by modern farmers who grow a variety of crops including barley, oats, maize, hay and potatoes and locally raise and graze domestic stock including cattle, sheep, goats, horses and pigs (Halpern 1967; Greenfield 1986; Cox 2002, 6; Griffiths *et al.* 2004; Milutinović *et al.* 2010, 628).

History of research and site size

The site was first investigated during 1986 when the Museum of Kruševac conducted a brief survey. From 1987–1989, Svetozar Stanković of the University of Beograd (Center for Archaeological Research) conducted systematic excavation of the site (Stanković 1988a; 1988b; 1988c; 1989). Stragari is a relatively small Middle Neolithic settlement from the early Vinča culture (phases A and B) of c. 4 ha (Stanković 1989, 29). A number of trenches across the site excavated approximately 170 m² (Fig. 22.2). The deposits extended up to a depth of 1.70 m below the modern surface, which was under plough cultivation (Stanković 1988b; 1988c; 1989).

Temporality

Three cultural horizons (Starčevo, Vinča-Tordoš I and II, and Late Bronze Age) have been defined at the site based on chronotypological classifications of the stratigraphically contextualised and associated ceramic artefacts (Stanković 1988b, 95; Greenfield personal records). The vast majority of archaeological (and faunal) remains belong to the earlier Vinča-Tordoš phase (Table 22.1), which is the subject of this essay.



Fig. 22.1. Map of region showing location of Stragari-Šljivik and other sites mentioned in the text.

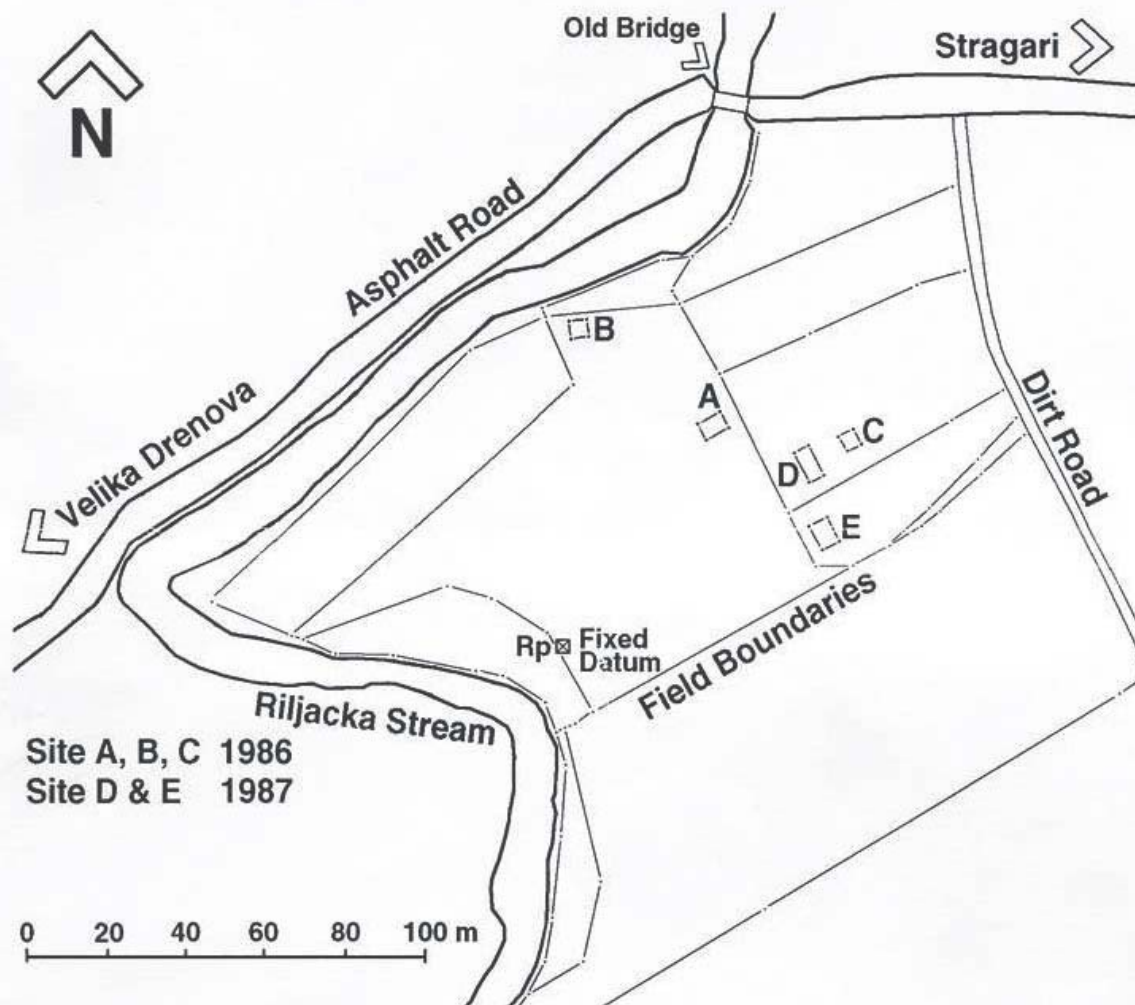


Fig. 22.2. Map of Stragari-Šljivik and location of 1986–1987 trenches (called Sites A–E).

The Vinča culture was the major Middle and Late Neolithic culture complex of the region. It spanned much of SE Europe, including Serbia, Bosnia, and parts of Croatia, Romania and Hungary (Orton 2012, fig. 1), with local variants in Bulgaria and Macedonia. The Vinča culture is known for its distinct pottery tradition, settlement pattern (long houses arranged in rows), intensive exploitation of local resources, and early adoption of copper metallurgy (Chapman 1981; Garašanin 1983; Boyadziev 1995; Orton 2008; 2012). It is usually subdivided through two major chronotypological schemes into Middle Neolithic Vinča-Tordoš I and II and Late Neolithic Vinča-Pločnik I and II phases (Garašanin 1951; 1973) or into Middle Neolithic Vinča A and B and Late Neolithic Vinča C and D phases (Milojčić 1949). The differences between the schemes are of limited relevance for zooarchaeological analysis of settlement remains, but that of Garašanin is followed here as it was used by Stanković in his chronostratigraphic analysis and in the publications cited above. The Middle Neolithic of Serbia is temporally synchronous with the Late Neolithic of Bulgaria and the early Late Neolithic of Greece.

Table 22.1. Taxonomic frequency by period (NISP)

Taxa	Starčevo		Starčevo-Vinča		Vinča-Tordoš I		Late Bronze Age	
	No.	%	No.	%	No.	%	No.	%
Domestic	4	6.90	6	5.22	751	8.26	1	1.96
<i>Bos taurus</i>	2	3.45	4	3.48	468	5.14	1	1.96
<i>Canis familiaris</i>		0.00		0.00	16	0.18		0.00
<i>Capra hircus</i>		0.00		0.00	8	0.09		0.00
<i>Ovis aries</i>		0.00		0.00	26	0.29		0.00
<i>Ovis/Capra</i>		0.00	1	0.87	65	0.71		0.00
<i>Sus scrofa dom.</i>	2	3.45	1	0.87	168	1.85		0.00
Wild	18	31.03	21	18.26	2374	26.10	14	27.45
Aves – wild		0.00		0.00	2	0.02		0.00
Mammalia – wild	18	31.03	21	18.26	2362	25.96	14	27.45
<i>Bos primigenius</i>		0.00		0.00	86	0.95	1	1.96
<i>Canis lupus</i>		0.00		0.00	2	0.02		0.00
<i>Capreolus capreolus</i>	8	13.79	9	7.83	506	5.56	2	3.92
<i>Castor fiber</i>		0.00		0.00	15	0.16		0.00
<i>Cervus elaphus</i>	10	17.24	11	9.57	1586	17.43	10	19.61
<i>Felis silvestris</i>		0.00		0.00	2	0.02		0.00
<i>Lepus europaeus</i>		0.00		0.00	3	0.03		0.00
<i>Martes martes</i>		0.00		0.00	1	0.01		0.00
<i>Meles meles</i>		0.00		0.00	3	0.03		0.00
<i>Sus scrofa fer.</i>		0.00	1	0.87	147	1.62	1	1.96
<i>Ursus arctos</i>		0.00		0.00	4	0.04		0.00
<i>Vulpes vulpes</i>		0.00		0.00	1	0.01		0.00
Carnivore – small		0.00		0.00	1	0.01		0.00
Mammal – small		0.00		0.00	3	0.03		0.00
Rodent (unid. sp)		0.00		0.00	2	0.02		0.00
Mollusca		0.00		0.00	4	0.04		0.00
<i>Unio pictorum</i>		0.00		0.00	3	0.03		0.00
<i>Helix sp.</i>		0.00		0.00	1	0.01		0.00
Pisces		0.00		0.00	5	0.05		0.00
<i>Fish (unidentified sp)</i>		0.00		0.00	5	0.05		0.00
Reptilia		0.00		0.00	1	0.01		0.00
<i>Emys orbicularis</i>		0.00		0.00	1	0.01		0.00
Not applicable		0.00		0.00	4	0.04		0.00
<i>Homo sapiens</i>		0.00		0.00	4	0.04		0.00

	<i>Starčevo</i>		<i>Starčevo-Vinča</i>		<i>Vinča-Tordoš I</i>		<i>Late Bronze Age</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Unknown	36	62.07	88	76.52	5968	65.60	36	70.59
Bos sp.		0.00		0.00	8	0.09	1	1.96
Bos/Cervus		0.00	4	3.48	224	2.46		0.00
Canis familiaris/lupus		0.00		0.00	1	0.01		0.00
Ovis/Capra/Capreolus	1	1.72	1	0.87	52	0.57		0.00
Sus scrofa		0.00		0.00	18	0.20		0.00
Unknown	9	15.52	8	6.96	2001	22.00	11	21.57
Mammal – large	26	44.83	62	53.91	2775	30.50	16	31.37
Mammal – medium		0.00	12	10.43	886	9.74	8	15.69
Mammal – small		0.00	1	0.00	3	0.03		0.00
Mammal – very small		0.00	1	0.87		0.00		0.00
Grand Total	58	100.00	115	100.00	9097	100.00	51	100.00

Stragari is important in that the faunal remains overwhelmingly date to the earliest Vinča phase (Vinča-Tordoš I), for which there are no other significant assemblages. Hence, it will contribute to our understanding of the evolution of this vital and long-lived Neolithic culture. While the Vinča culture has been most recently dated to *c.* 54/5300–4600 cal BC, the Vinča-Tordoš I phase is thought to be relatively short, spanning *c.* 100 years around *c.* 54/5300–5200 cal BC (Borić 2009, 232–234; Orton 2012, 191). The remains from this horizon at Stragari will be the focus of this paper.

Nature of deposits

The architectural features include a Starčevo culture pit house, a pit (probably another pit house) containing remains from either the Starčevo-Vinča transition or mixing of Starčevo and Vinča materials; pits, bedding trenches and house floors from the Vinča-Tordoš I horizons; and an intrusive burial from the Late Bronze Age. Artefacts and ecofacts were associated with each of the features. Unfortunately, there are no published or unpublished comprehensive maps of all features and excavation units from the site that allow a spatial analysis to be undertaken at this time.

Methods of analysis

Initially, the faunal remains were coded in the field using an ASCII format on a DOS computer with a floppy disk drive. Subsequently, the data were reorganised and migrated into Excel. Many variables were coded for in the analysis including taxonomic, element, part, face, symmetry, fusion, age, sex and pathology. Taphonomic variables include weathering, butchering, tool/ornament use and use-wear polish. The taxonomic identifications were mostly made with the aid of various osteological manuals (e.g. Schmid 1972; Stanojević 1975a; 1975b; 1976a; 1976b) and the comparative skeletal collection that I assembled at the Petnica Science Centre in Serbia, which appears still to be in productive use (Orton 2008, 52).

The age-at-death was determined for most ageable specimens from a combination of fusion and tooth development using standard studies available at the time (e.g. Silver 1969; Bökönyi 1970; Payne 1973; Grant 1975). Five major categories were defined: foetal, infant, juvenile, subadult and adult. Sexing was rarely possible except when sex-specific elements were available (e.g. crania with antlers or horns, innominates). Biometric data were collected, but are not presented in this analysis, using the

standards of the day (von den Driesch 1976; Greenfield 1986).

The number of fragments, elements and NISPs for all remains was collected. For this study, all remains are quantified using NISP (absolute and relative frequencies, unless other specified), after all possible articulations in an associated deposit were checked for articulations or joins. A fused radius/ulna would only be counted once. Each bag of bones was weighed to determine the total bone weight of the deposit (Greenfield 1986).

The faunal assemblage was destroyed in a basement flood in the City Museum (Gradski Muzej) in Trstenik where it had been stored. All the labels were damaged and the remains were discarded. A selection of bone tools had been better curated (Vitezović 2009; 2010). A small sample of other remains (e.g. teeth for ageing and selected taxa) was exported and is curated at the University of Manitoba where they have been the subject of a number of research papers by my students and myself (Greenfield 2005; Arnold and Greenfield 2006; Greenfield and Arnold 2014).

Assemblage analysis

Many variables affect the preservation of the assemblage and its interpretation. Both natural and cultural variables can bias the record. Several of these are discussed next.

Modern taphonomic variables - excavator recovery behaviour

During excavation, all of the remains were recovered by hand. None of the sediments was sieved or floated. The recovery method undoubtedly biases the sample towards larger taxa and larger bones of all taxa. It probably underrepresents the smaller bones and the smaller taxa such as birds, rodents and fish. Very few of these smaller taxa and elements are present (Table 22.1). Only five specimens of fish (0.2%) were recovered, but this low frequency may not result from poor recovery since the site is not on a major river or near a large body of water. Few fish remains are recovered on such sites located far from large water bodies suitable for aquatic exploitation (e.g. Clason and Prummel 1977; Greenfield 1986; Legge 1990; Jongsma and Greenfield 1996; Orton forthcoming). The same is true for birds, which are recovered relatively rarely in assemblages, even when sieved.

The effect of hand recovery is most telling when element size of mammals is considered (Table 22.2). If just large mammals, such as cattle, are considered, some small elements are under-represented relative to their frequency in the overall skeleton. For example, carpals, tarsals and phalanges together make up 32% of the corrected number of cattle remains, compared with the 60% expected in fully recovered whole skeletons, but not all small elements are underrepresented. Carpals are woefully under-represented (3% versus expected 11%), as are phalanges (22% versus 42%), but tarsals more or less match their expected frequency (*c.* 7%). Similarly, for medium-sized mammals such as pigs, all small elements (e.g. phalanges, carpals, tarsals) are under-represented, while many larger elements (most long bones, mandible) are over-represented.

Table 22.2. Frequency distribution of domestic cattle and pig remains by element (NISP)

<i>Element</i>	<i>Bos taurus</i>		<i>Bos taurus corrected*</i>		# in skeleton		<i>Sus scrofa dom.</i>		<i>Sus scrofa dom. corrected*</i>		# in skeleton	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
Carpal	10	2.16	10	3.09	6	10.53	0	0.00	0	0.00	6	6.19
Cranial	22	4.76	22	6.79	1	1.75	22	13.66	22	18.03	1	1.03
Femur	11	2.38	11	3.40	2	3.51	7	4.35	7	5.74	2	2.06
Fibula	0	0.00					1	0.62	1	0.82	2	2.06
Humerus	13	2.81	13	4.01	2	3.51	16	9.94	16	13.11	2	2.06
Innominate	15	3.25	15	4.63	2	3.51	3	1.86	3	2.46	2	2.06
Loose tooth: lower	33	7.14					11	6.83		0.00		
Loose tooth: upper	49	10.61					5	3.11		0.00		
Mandible	33	7.14	33	10.19	2	3.51	13	8.07	13	10.66	2	2.06
Metacarpus	17	3.68	17	5.25	2	3.51	3	1.86	3	2.46	8	8.25
Metatarsus	40	8.66	40	12.35	2	3.51	6	3.73	6	4.92	8	8.25
Patella	0	0.00			2	3.51	1	0.62	1	0.82	2	2.06
Phalange	72	15.58	72	22.22	24	42.11	16	9.94	16	13.11	48	49.48
Radius	18	3.90	18	5.56	2	3.51	6	3.73	6	4.92	2	2.06
Rib	10	2.16			24**		6	3.73		0.00	24**	
Scapula	19	4.11	19	5.86	2	3.51	12	7.45	12	9.84	2	2.06
Tarsal	22	4.76	22	6.79	4	7.02	4	2.48	4	3.28	6	6.19
Tibia	12	2.60	12	3.70	2	3.51	4	2.48	4	3.28	2	2.06
Ulna	20	4.33	20	6.17	2	3.51	8	4.97	8	6.56	2	2.06
Vertebra	46	9.96			48**		17	10.56		0.00	48**	
Grand Total	462	100.00	324	100.00	129	100.00	161	100.00	122	100.00	169	100.00
Carpals, tarsals, phalanges combined				32.10		59.65						61.86
Corrected*					57						97	

* Corrected = crania, ribs, vertebrae, fibulae, teeth not counted. ** Average figures.

Natural variables: weathering, soil conditions and gnawing

The bones from Stragari are unusually well preserved, thanks partly to a favourable burial environment (largely alluvial and soft brown forest soils with moderate pH) and partly to rapid burial (98.6% exhibit light or medium and only 1.3% heavy weathering). It is unknown whether the more weathered specimens were from exterior (open-air) contexts as at Vinča (Greenfield and Jongsma-Greenfield 2014). Two specimens (0.02%) had water smoothed surfaces.

A relatively small number of bones exhibited signs of gnawing (n=377; 4.1%), overwhelmingly by canids with one case of rodent gnawing. Gnawing was mostly light (83.6%) and only infrequently medium (8.2%) or heavy (7.1%), so is unlikely to have affected assemblage composition significantly. There is no indication that canids had preferential access to particular taxa or body parts.

Cultural taphonomic variables

Burning

The frequency of burned bones (13.8%) is very high compared to other reported Starčevo and Vinča culture assemblages from the region, most of which have less than 5% burned remains (Greenfield 1986; 1991; 2008). For one assemblage with a much higher reported frequency of burned remains, that from Megalo Nisi Galanis in Macedonia to the south of the Vinča distribution, it was difficult to

distinguish burning from mineral staining (Greenfield and Fowler 2005; Shahack-Gross *et al.* 1997). At Stragari, most burnt fragments were not identifiable to body part and taxon, or only coarsely so (e.g. long bone, medium mammal). Burning was observed for all parts of the skeleton, however, and all common taxa, but was recorded more frequently for red deer (14.2%) and roe deer (11.7%) than domestic cattle (3.4%), sheep/goats (4.0%) or pigs (6.5%).

Butchering

Only 2% of the assemblage exhibited butchery traces, including 175 fragments with slice marks and four with chop marks. Among the commonest taxa, butchery marks are most frequent in aurochs (12.9%), less so in domestic cattle (5.5%), wild boar (5.4%) and red deer (5.1%), and rare in roe deer (2.2%), sheep/goat (1.0%) and domestic pig (0.6%). Intensity of butchery thus seems related to carcass size.

Bone size and fragmentation

Bone size can be used as a proxy indicator of bone fragmentation in food preparation and other activities, and also in post-discard processes. The completeness of bone fragments was recorded as complete, $\geq 3/4$, $\geq 1/2$, $\geq 1/4$ or $< 1/4$. The vast majority of remains were less than $1/4$ of their original size ($n=6485$; 71.3%). This is followed more or less in descending order by $\geq 1/4$ ($n=833$; 9.2%), $\geq 1/2$ ($n=828$; 9.1%), $\geq 3/4$ ($n=305$; 3.3%) and whole bones ($n=617$; 6.8%). Complete specimens were largely restricted to the small limb bones, such as carpals, tarsals, and phalanges, while most of the assemblage (and especially the more fragile cranial material – Lyman 1994) fell into the most incomplete category ($< 1/4$). Nonetheless, fragments accounting for half or more of the complete bone make up nearly 20% of the assemblage, a much greater proportion than in most other Vinča assemblages. Most cranial remains ($n=6169$; 75.1%) are fragmented to $< 1/4$ of their original size, compared with only a minority of post-cranial remains ($n=316$; 35.7%). This contrast probably reflects the biomechanics of bone, rather than a difference in food preparation patterns since crania are more fragile. Degree of fragmentation varied between taxa but did not appear to correlate with body size.

Cultural modification

A few bones (101; 1.1% of the assemblage) had been (possibly) modified as tools and/or ornaments. Of these, 69.3% exhibited use-wear polish, which was observed very rarely (0.3%) in the unmodified material. The implication is that most of the bone assemblage was not culturally modified, even haphazardly, but resulted from food-processing.

Sample size

Of the total assemblage from Stragari of 9321 NISP, most (9097) were recovered from the Vinča-Tordoš horizon and far fewer from the Starčevo (58), mixed Starčevo-Vinča (115), and Late Bronze Age (51) deposits (Table 22.1). The periods other than Vinča-Tordoš are not the focus of this report.

Taxonomic class/phylum

Despite the recovery technique, there is enough taxonomic class/phylum-level diversity to infer what

might have been lost. Mammals are the majority of the assemblage (99.9%), followed by fish, shellfish, birds and reptiles. Comparison with more systematically collected assemblages (e.g. Selevac, Gomolava) suggests that the non-mammalian classes/phyla would originally have been more abundant (Clason and Prummel 1977; Legge 1990).

Domestic versus wild

Of the osteological remains identifiable to a more or less precise taxon, many could be assigned to domestic or wild status (Table 22.1). Wild animals (76%) clearly dominate over domesticates (24%), in strong contrast to nearby Early Neolithic Blagotin (Greenfield and Jongsma-Greenfield 2014). In most other Neolithic assemblages, wild dominate only when there are substantial numbers of fish, which is not the case at Stragari. Yet Stragari is a typical Vinča culture settlement with architectural evidence suggesting residential stability and year-round occupation, rather than a specialised satellite community. Clearly, the wild mammalian fauna was abundant enough to support the local community.

Taxonomic diversity

Although bird and fish specimens are not precisely identified to taxon, and all their elements are assigned a NISP of 1 (Table 22.1), the taxonomic diversity of the assemblage (at least 24 different taxa) is far higher than in most Early Neolithic (Greenfield 2008) or Middle and Late Neolithic (e.g. Greenfield 1986; 1991; Bökönyi 1988; Legge 1990; Jongsma and Greenfield 1996) assemblages. This is largely because the diversity of wild taxa is far greater than in most Neolithic food producing cultures of the region.

Taxonomic frequency

The most common taxon in the assemblage was red deer (50.8%), followed by roe deer (16.2%), domestic cattle (15.0%), domestic pig (5.4%), boar (4.7%), aurochs (2.7%), and sheep/goat (3.2%), while all other taxa are represented by less than 1%. For a Middle Neolithic Vinča assemblage, the dominance of red deer and abundance of roe deer are unique and are not inflated by the curation or identifiability of antler, as frequencies on postcranial specimens alone are almost identical (51.5% and 17.1%, respectively). Boar and aurochs are also well represented, while bear, hare, beaver, wolf, marten, cat, fox, pond tortoise, bird and fish occur rarely. Of the usual range of Neolithic domestic taxa, cattle are most common (15.0%), followed by pigs (5.4%), sheep and goats (3.2% in a ratio of approximately 3:1), and finally dogs (0.5%), but these frequencies are far lower than in contemporary sites.

Age and season of death of most common taxa

In the following analysis, indeterminate age categories such as subadult/adult are excluded as not indicative of exploitation strategies (Greenfield 1988; 2005), while infants and juveniles may be combined into a very immature category to compensate for the differential attrition of the youngest age classes.

Ovis/Capra

Although samples are small, the distribution of all ageable elements differs between sheep and goats (Table 22.3): 25% subadult and 75% adult in goats; and 20% juvenile, 60% subadult, and 20% adult in sheep. The distribution for indeterminate sheep/goat, three quarters of which are presumably sheep, is intermediate between those for the two species taken separately: 16% very immature, 34% subadult, and 50% adult. While the sheep data suggest exploitation of primary products, greater emphasis on secondary products is possible for goats.

Following Payne (1973), dental specimens ageable only approximately have been allocated to age classes proportionately (Table 22.4). At the time of analysis, few criteria for distinguishing sheep and goat dentition were available. Of the mandibular remains identified morphologically to goat or sheep, none of the former and only four of the latter (all less than 18 months) could be assigned to a specific age class, so the two taxa are combined here for discussion of the dental harvest profile. Mortality is concentrated in age classes C (6–12 months: 27%), D (1–2 years: 32%) and F (3–4 years: 28%), with a surprising absence of evidence for older age classes (4–10 years). Adults are well represented among postcranial material, however, and the Stragari profile otherwise resembles those from earlier and later Neolithic sites (Greenfield 2005; Arnold and Greenfield 2006; Orton 2008) in most closely matching Payne's (1973) herd exploitation model for primary products.

Bos taurus

Ageable cranial and post-cranial elements combined indicate modest juvenile (11.5%), more substantial subadult (29%) and heavy adult (59%) mortality among domestic cattle (Table 22.3). This distribution is very similar to that at other Middle and Late Neolithic sites, such as Opovo, Petnica, Anzabegovo, and Gomolava (Greenfield 1986; 1991; 2005; Orton 2008). Involving less adult mortality than in post-Neolithic contexts, it might represent exploitation of a mixture of primary and secondary products (Legge 1981; 1990; 1994; 2005). If cattle were milked (and milk lipids have been found in Neolithic ceramics from the region), this was arguably on a dramatically lesser scale than in subsequent periods (Greenfield 2005; 2010; 2014). Cattle may have been exploited for another secondary product, traction, since there was no other large domestic animal at this time capable of moving heavy loads.

The dental harvest profile for cattle (Table 22.4) documents a few infant deaths (Class A; 0–1 month: 7%), possibly slaughtered to make milk available for humans, but otherwise broadly matches the picture from all ageable elements, with 41% mortality in Classes C–D (8–36 months) and 52% in Classes G–I (adulthood–senility). This pattern is very similar to that from Middle Neolithic (Vinča-Tordoš B) levels at Petnica (Greenfield 2005; Arnold and Greenfield 2006) and again suggests exploitation for primary and also some secondary products.

Table 22.3. Frequency distribution of taxa by major age groups (NISP) without indeterminates (e.g. juvenile/subadult and subadult/adult)

Taxa	Sum of NISP						%						
	Foetus	Foetus/ Infant	Infant	Juvenile	Subadult	Adult	Foetus	Foetus/ Infant	Infant	Juvenile	Subadult	Adult	Total
Domestic	1	6	2	77	156	228	0.21	1.28	0.43	16.38	33.19	48.51	470
<i>Bos taurus</i>			1	32	81	165	0.00	0.00	0.36	11.47	29.03	59.14	279
<i>Canis familiaris</i>					1	9	0.00	0.00	0.00	0.00	10.00	90.00	10
<i>Capra hircus</i>					1	3	0.00	0.00	0.00	0.00	25.00	75.00	4
<i>Ovis aries</i>				3	9	3	0.00	0.00	0.00	20.00	60.00	20.00	15
<i>Ovis/Capra</i>		3		4	15	22	0.00	6.82	0.00	9.09	34.09	50.00	44
<i>Sus scrofa dom.</i>	1	3	1	38	49	26	0.85	2.54	0.85	32.20	41.53	22.03	118
Wild			1	33	243	929	0.00	0.00	0.08	2.74	20.15	77.03	1206
<i>Bos primigenius</i>					11	62	0.00	0.00	0.00	0.00	15.07	84.93	73
<i>Canis lupus</i>						1	0.00	0.00	0.00	0.00	0.00	100.00	1
<i>Capreolus capreolus</i>				7	41	162	0.00	0.00	0.00	3.33	19.52	77.14	210
<i>Castor fiber</i>					3	9	0.00	0.00	0.00	0.00	25.00	75.00	12
<i>Cervus elaphus</i>			1	23	167	599	0.00	0.00	0.13	2.91	21.14	75.82	790
<i>Felis silvestris</i>						2	0.00	0.00	0.00	0.00	0.00	100.00	2
<i>Lepus europaeus</i>						1	0.00	0.00	0.00	0.00	0.00	100.00	1
<i>Martes martes</i>						1	0.00	0.00	0.00	0.00	0.00	100.00	1
<i>Meles meles</i>						3	0.00	0.00	0.00	0.00	0.00	100.00	3
<i>Sus scrofa fer.</i>				3	21	85	0.00	0.00	0.00	2.75	19.27	77.98	109
<i>Ursus arctos</i>						3	0.00	0.00	0.00	0.00	0.00	100.00	3
<i>Vulpes vulpes</i>						1	0.00	0.00	0.00	0.00	0.00	100.00	1
Grand total	1	6	3	110	399	1157	0.06	0.36	0.18	6.56	23.81	69.03	1676

Sus scrofa dom.

For domestic pigs, all ageable elements indicate peak mortality among juveniles (32%) and subadults (42%), with fewer adults (22%) and very few infants (Table 22.3). Ageable mandibles include one of 2–7 months, two of 7–14 months, one of 14–21 months, and two of 14–27 months (Arnold and Greenfield 2006, appendix A table B33). As usual with this species that offers no secondary products, both datasets indicate emphasis on slaughter of immature animals (Greenfield 1988).

Cervus elaphus and *Capreolus capreolus*

For both red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*), all ageable elements combined (Table 22.3) provide evidence of few juveniles (3% of each species), more subadults (21% and 20%), and a clear majority of adults (76% and 77%). In a domestic population, such a preponderance of adults might suggest specialised secondary products exploitation (as for goats – above), but wild taxa are not exploited in this manner. In this case, where hunters exploited deer for their meat, hide, and antler/bone, they focused on adults to maximise energy returns.

Seasonality

In terms of elevation, Stragari is a lowland site where livestock might be expected to overwinter, but with the possibility of transhumant movement to highland areas roughly from May to September. If

lambling and calving were concentrated as in recent times in early spring (say, February–April), the absence of young age classes might indicate seasonal movement of herds away from the site.

Among sheep and goats, the 0–2 month age class, probably representing spring deaths, is absent, but this might be due to partial (unsieved) recovery (although such remains are present in other unsieved or partially sieved samples – Arnold and Greenfield 2006) or attrition (particularly heavy in the youngest age classes – cf. Munson 2000). Deaths in the following age classes (2–6 and 6–12 months) suggest that sheep and goat herds were present around Stragari for the majority of the year and did not take part in summer transhumance to the highlands. For cattle, dental data indicate that the youngest age class (0–8 months) is present, while the next (8–18 months) is absent, but these classes are too broad to shed secure light on seasonality of slaughter and thus on possible herd mobility. In the case of pigs, infant remains are very scarce but not absent, while the mandibular sample is far too small to shed light on seasons of slaughter.

Table 22.4. Bos taurus and Ovis/Capra mandibular eruption and wear

<i>Age classes</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>	<i>G</i>	<i>H</i>	<i>I</i>		
<i>Sheep/goat suggested age (yrs) (after Payne 1973)</i>	<i>0–2 months</i>	<i>2–6 months</i>	<i>6–12 months</i>	<i>1–2 years</i>	<i>2–3 years</i>	<i>3–4 years</i>	<i>4–6 years</i>	<i>6–8 years</i>	<i>8–10 years</i>	<i>Total</i>	<i>Data type</i>
<i>Ovis aries</i>	0	1	2	0	0	0	0	0	0	3	Raw count
<i>Ovis aries</i>	0	1	3	0	0	0	0	0	0	4	Corrected
<i>Ovis/Capra</i>	0	1	3	5	1	7	0	0	0	17	Raw count
<i>Ovis/Capra</i>	0	1	3.9	8.3	1.4	7.3	0	0	0	21.9	Corrected
<i>Ovis/Capra combined</i>	0	2	5	5	1	7	0	0	0	20	Raw count
<i>Ovis/Capra combined</i>	0	2	6.9	8.3	1.4	7.3	0	0	0	25.9	Corrected
<i>Ovis/Capra combined</i>	0.00	10.00	25.00	25.00	5.00	35.00	0.00	0.00	0.00	100.00	Raw count
<i>Ovis/Capra combined</i>	0.00	7.72	26.64	32.05	5.41	28.19	0.00	0.00	0.00	100.00	Corrected
<i>Cattle suggested age (years) (after Halstead 1985)</i>	<i>0–1 month</i>	<i>1–8 months</i>	<i>8–18 months</i>	<i>18–30 months</i>	<i>30–36 months</i>	<i>young adult</i>	<i>adult</i>	<i>old adult</i>	<i>senile</i>	<i>Total</i>	<i>Data type</i>
<i>Bos taurus</i>	2	0	6	2	0	0	1	0	1	12	Raw count
<i>Bos taurus</i>	2	0	7.5	4.3	0	0	9.2	0	6	29	Corrected
<i>Bos taurus</i>	16.67	0.00	50.00	16.67	0.00	0.00	8.33	0.00	8.33	100.00	Raw count
<i>Bos taurus</i>	6.90	0.00	25.86	14.83	0.00	0.00	31.72	0.00	20.69	100.00	Corrected

Red and roe deer antler and frontal bones can also provide indications of site seasonality. Both species shed their antlers in late autumn/early winter (*c.* November), before the winter stress period. Three of seven red deer and thirteen of fourteen roe deer antlers are still attached to the cranium, implying kills and settlement occupation during the warm season, while the remainder were shed, perhaps indicating winter kills – if shed antlers were not collected as useful raw material.

Conclusions

The analysis of mortality patterns, on which Tony Legge carried out such pioneering work, suggests that the management of domesticates at Middle Neolithic Stragari emphasised primary products of sheep and pigs, possibly secondary products of goats, and a mixture of primary and secondary products of cattle. In this respect, Stragari did not differ significantly from other broadly contemporary sites in the same region. The assemblage stands out, however, for its heavy predominance of wild mammals, particularly red deer but including a wide range of other species. Vinča faunal assemblages vary in

composition from near total reliance upon domesticates to a balance of wild and domestic as at Opovo, Petnica and Sinandrei (*cf.* Greenfield 1986; 1991; 2008; Greenfield and Jongsma 2008; Greenfield and Jongsma-Greenfield 2014), but emphasis on hunting at Stragari is exceptional.

How does one explain the dominance of wild fauna at Stragari? Usually, wild fauna are considered an essential (but minor) part of Neolithic subsistence, mediating seasonal and inter-annual resource fluctuations (e.g. Bogucki 1982; Gregg 1988; Glass 1991; Orton forthcoming). In the case of Stragari, however, hunting dominated the animal component of subsistence. In general, northern Vinča sites have a greater reliance upon wild animals than southern, as comparison of sites in Romania and ex-Yugoslavian Macedonia shows (Bökönyi 1976; Greenfield 1991; Jongsma and Greenfield 1996), while lowland sites *tend* to have more wild fauna than those at mid-altitude (Greenfield 1986; 1991; Jongsma and Greenfield 1996; Orton 2008; forthcoming), but neither latitude nor altitude explains the extreme composition of the Stragari assemblage. Unlike sites in the Iron Gates, Stragari did not have access to rich aquatic resources, nor is there any reason to regard its immediate environs as more favourable to terrestrial game (or less favourable to livestock) than other parts of the rolling hills of lowland central Serbia. Wild fauna also dominates in Early Neolithic levels at Stragari (82% of only 22 NISP – Table 22.1) and nearby at Bukovačka Česma (Greenfield 1994), but not at Blagotin, only a few kilometres upstream, nor at Divostin and other sites in the same region (e.g. Bökönyi 1988; Greenfield and Jongsma-Greenfield 2014).

There is no evidence that Stragari represents the remains of a different culture (e.g. of remnant hunter-gatherers). Equally, the size of the settlement (100 × 200 m), the nature of occupation (typical densely packed houses; thick deposits implying residential stability), and faunal indications of occupation in different seasons all point to Stragari being a substantial village rather than a specialised seasonal hunting camp of other Vinča settlements.

In general, terrestrial wild resources were more important at Middle and Late Neolithic Vinča sites than at Early Neolithic sites in the same region, but Stragari demonstrates greater variability in Neolithic animal exploitation than has previously been recognised and highlights the need for caution in assumptions that hunting played only a secondary role in the economic strategies of these ‘food-producing’ societies.

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Many years after I first met Tony, my wife Tina Jongsma-Greenfield was studying for her zooarchaeological PhD at the University of Cambridge in the year before Tony passed away. She too was able to benefit from his erudition and generosity towards junior colleagues. He will be missed

sorely.

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Part V

Prehistoric Britain

To the Upper Lake: Star Carr revisited – by birchbark canoe

Peter Rowley-Conwy

Introduction

Tony Legge instigated the re-analysis of the animal bones from Star Carr that led to our joint volume (Legge and Rowley-Conwy 1988). I worked as his post-doc on the Tell Abu Hureyra project, in which we had been developing methods such as tooth eruption and bone growth to look at seasonality. Tony had always felt that a re-analysis of the Star Carr fauna, using these methods, would be a worthwhile project, and I well remember the day in 1983 when we went to ask Grahame Clark if he had any objection to our revisiting the bones. ‘Oh no, that’s all history now,’ was Clark’s response. So we got to work.

We concluded that Star Carr was occupied in late spring and early summer, not winter and early spring as had been previously believed. We also argued, on the basis of skeletal element frequencies, that Star Carr was a logistic site, not a residential location; specifically, that it was a hunting camp from which meat had been removed and taken away for consumption elsewhere.

Two major developments have taken place over the last three decades. First, many more sites have been located around the prehistoric Lake Flixton. The Seamer Carr Project excavated a series of sites at Seamer Carr (Schadla-Hall 1987; 1989), and the Vale of Pickering Research Trust has examined the rest of the lake shore (summarised in Milner *et al.* 2011). Figure 23.1 (top) plots the sites as now known. None of these sites is a ‘new Star Carr’; all have produced much smaller collections of material including some faunal remains. This has been accompanied by detailed ecological surveys of the lake-edge itself (Cloutman 1988a; Cloutman 1988b; Cloutman and Smith 1988; Taylor 2011). Second, the Star Carr site itself has been shown to be larger than Clark envisaged, encompassing several areas of activity (Mellars and Dark 1998), including a considerable spread of split timbers and a dwelling structure (Conneller *et al.* 2012). These developments allow Star Carr to be viewed in its local context.

In this contribution I will explore some aspects arising from this. I will argue for a new model of hunter-gatherer subsistence and settlement in Preboreal north-eastern England – based on the central importance of the birchbark canoe.

Logistic hunter-gatherers at Lake Flixton

The argument that Star Carr was a logistic hunting camp was based on skeletal element frequency,

which suggested that the meatier parts of the animals had been removed. For red deer, this involved the haunch: pelvis, femur, and proximal tibia. For the aurochs, the heavily muscled forequarters were removed along with the haunch (Legge and Rowley-Conwy 1988, 87–91) (see Fig. 23.2 top). Although some of these bones are relatively soft and can be destroyed, we argued that preservation conditions were good, and that dog gnawing was minimal, so these factors could not be blamed for the pattern (Legge and Rowley-Conwy 1988, 69–74). Bone grease or bone fat manufacture might also cause element destruction, but the recent excavation of a bone grease manufacturing feature involving bison bone indicates that the process would generate very large numbers of diaphyseal splinters, the majority below some 5 cm in length (Karr *et al.* 2015). Some discard of bone fragments certainly occurred during Clark’s excavation (Elliott and Milner 2010, 83), but if large numbers of fragments had been present it is unlikely that this would have escaped notice. The later excavations both at Star Carr and elsewhere in the Vale have not produced very large numbers of such fragments. Bone grease manufacture is thus probably not the cause of the pattern.

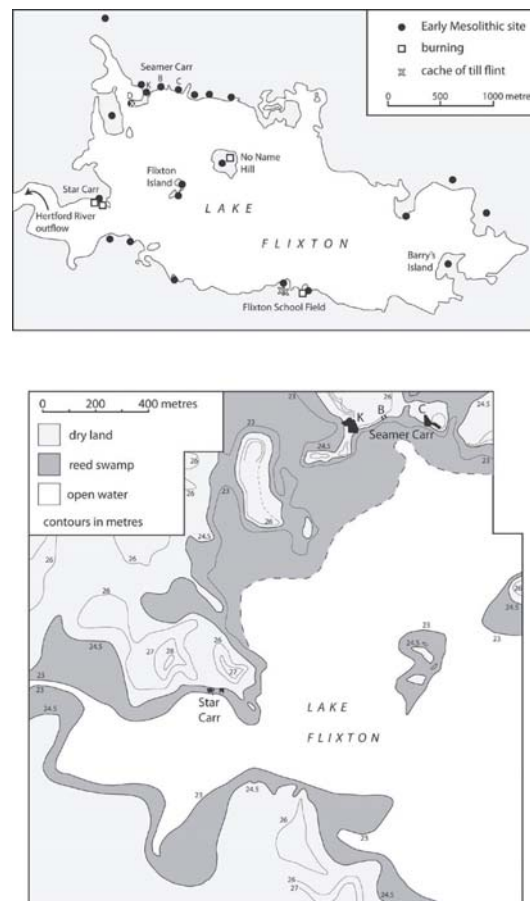


Fig. 23.1. Top: outline map of Lake Flixton in the Preboreal. Lake outline and sites redrawn from Taylor (2011, fig. 3). Sites showing evidence of clearance by burning from Dark (1998a) and Cummins (2000). Flint cache sites from Conneller and Schadla-Hall (2003). Bottom: contour map of the western end of Lake Flixton, showing the likely extent of the reedswamp and site locations. Contours from Cloutman (1988a, figs 3 and 4); the 24.5 m line is taken as the shoreline, the 23 m line the edge of open water (following Cloutman 1988a, 17), except in the northern part where the reedswamp was wider; the dotted line follows Schadla-Hall (in Spratt 1993, fig. 26). The inner edge of the reedswamp at Seamer Carr would have merged into fen carr (Cloutman 1988b, fig. 7).

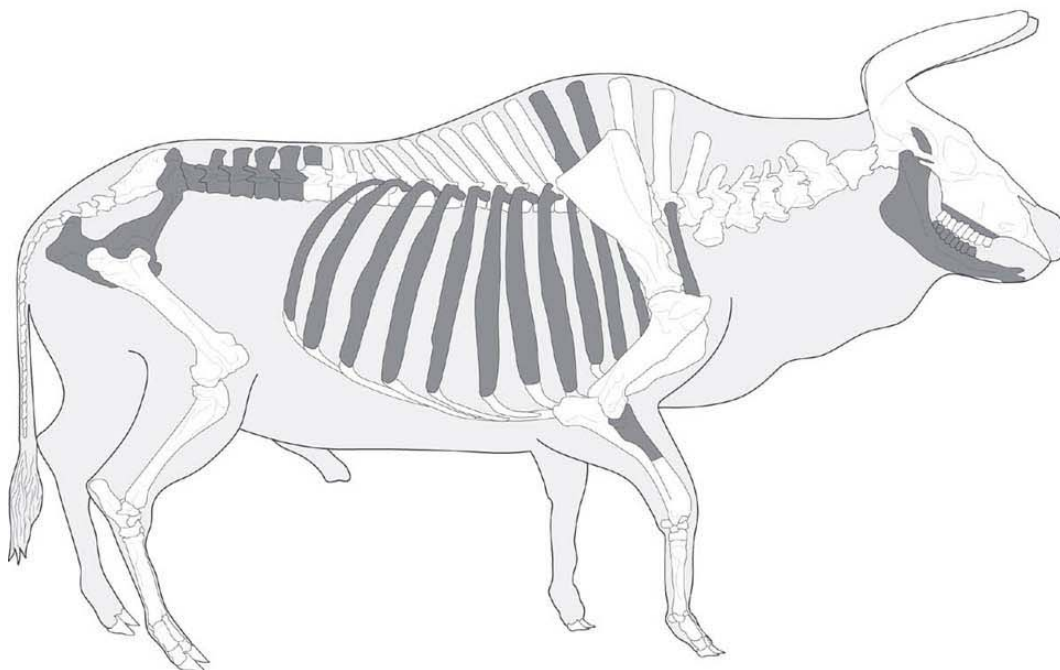
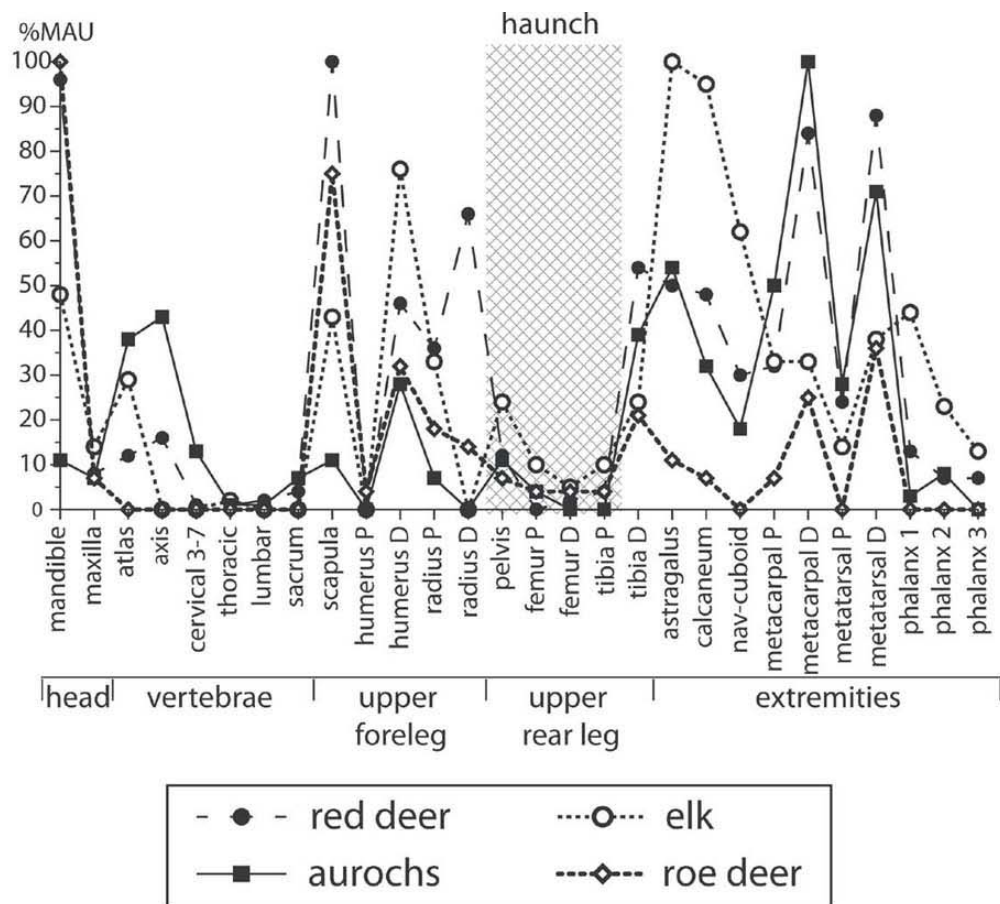


Fig. 23.2. Top: Skeletal element frequency of the four main species at Star Carr, showing the rarity of elements comprising the haunch (redrawn from Legge and Rowley-Conwy 1988, fig. 40). Bottom: Elements present at the aurochs butchery location at Seamer Carr site B (from Uchiyama et al. in press).

Support for the difference between the treatment of red deer and aurochs comes from the

differential treatment of caribou and bison in North America (discussed in Legge and Rowley-Conwy 1988, 87–91). Analogous patterns in deer bone frequencies have been found, and similar logistic arguments put forward, at both Arruda in Portugal (Rowley-Conwy 2015) and Awashimadai 1989 in Japan (Uchiyama 2015). Both these latter sites can be approached by water.

A group of bones from Seamer Carr site B adds to this. These comprise the articulated pelvis and lumbar vertebrae of an aurochs, with other bones closely associated: a right mandible and maxilla, a hyoid, a proximal right radius, four thoracic vertebrae, 15 rib fragments and the left and right pelvis. These were associated with a scatter of flint artefacts and all probably come from one single aurochs (Uchiyama *et al.* in press). The bones are plotted in Figure 23.2 (lower). These bones may represent the butchery of an aurochs in preparation for meat transport, because the pattern is similar to that at Star Carr except for the radius and the pelvis. Other sites argued to be aurochs butchery locations include Potsdam-Schlaatz, where all the vertebrae remained but the pelvis was absent (Gustavs 1987), and Balkweg, where only the vertebrae and the extremities remained (Prummel and Niekus 2011). Removal of the meaty elements of both fore- and hind limbs is common to all these three butchery sites.

If the above is correct, substantial quantities of meat were exported from Star Carr and Seamer Carr. The most practical means of doing this would be by canoe, because both the distance travelled and the weight carried can be dramatically increased (Ames 2002). Two aspects of the location of Star Carr support this. First, the site is by the outflow of the Hertford River from Lake Flixton. Second, Star Carr was placed with immediate access to relatively deep water close inshore, where the reed belt was at its narrowest (Fig. 23.1). Even a relatively narrow reed zone presents an impenetrable barrier to a canoeist seeking to land (Fig. 23.3). Easy canoe access to open water is thus argued to be the single crucial factor determining the location of Star Carr.

As Cloutman (1988a, 17) notes, Walker and Godwin (1954) established the presence of relatively deep water close to Star Carr. Cloutman himself confirmed this in detail, identifying ‘an open-water inlet’ at Star Carr (1988a, 18). Only a few metres to the east, in the area of the 1985 excavation, the reedswamp zone was broader (Cloutman 1988a, 17), emphasising the local nature of the inlet. Further north towards Seamer Carr the reedswamp was broader (Cloutman 1988b); the conclusion is that ‘[Star Carr] was chosen for its shelter and easy access to the lake. At no other place in the immediate area did the open water so closely approach the shore’ (Cloutman and Smith 1988, 55).



Fig. 23.3. Canoeist's-eye view of a dense reed swamp when approaching from the lake. The lily zone next to the reeds marks the transition to deeper water. Photo PR-C.

Figure 23.1 (bottom) is a tentative reconstruction of the western end of Lake Flixton during the period of occupation, based on Cloutman's work. Precise delineation of the shoreline is problematic, and in any case this presumably changed somewhat through time. The 23 m contour marks the shoreward edge of calcareous mud in the basin (Cloutman 1988a, 6), and the lake level would have been at or above this level (Cloutman 1988a, 17). Organic muds reached up to 24.5 m, and this is likely the maximum water level (Cloutman 1988a, 17 and fig. 13). Lake level was thus between 23 m and 24.5 m, and this zone contains many remains of *Phragmites* reeds. This zone is therefore suggested to be the main reed swamp in Figure 23.1, except in the shallow embayment towards Seamer Carr. In this region fen carr vegetation was already advancing towards the centre of Lake Flixton (Cloutman 1988b). The edge of the reed swamp here is taken from Schadla-Hall (in Spratt 1993, fig. 26) and marked by the dotted line in Figure 23.1.

The tentative nature of this reconstruction must be stressed, and the reed swamp zone would have changed through time. But Figure 23.1 (bottom) shows that deep-water access was better at Star Carr than in most other locations, supporting the importance of canoes. From this perspective, various other lines of evidence may be examined. Clark's (1954) 'brushwood platform' is now generally regarded as a natural accumulation (Coles and Orme 1983). However, a definite platform made of split planks was excavated in 1985–1989 (Mellars *et al.* 1998), and recent work suggests that it may extend as far as the edge of Clark's original excavation (Conneller *et al.* 2012). This major stabilisation of the lake edge can be interpreted as a canoe landing stage.

Repeated but localised burning has been detected in two pollen diagrams from Star Carr (Dark 1998a; 1988b), and from No Name Hill and Flixton School Field (Cummins 2000). These are marked in

Figure 23.1 (top). The reed belt was what was being burnt: Hather (1998) identified numerous charcoal fragments of *Phragmites australis*, the common reed. Reasons advanced to account for this include increasing visibility across the lake (Mellars and Dark 1998, 212); increasing fodder availability to attract grazing mammals (Day 1993, 132; Mellars 1998, 230–232); unspecified management practices (Taylor 2011, 68); accident (Day 1993, 132); and improved access to open water (Innes *et al.* 2011, 94).

Most of these reasons are rather unlikely. Visibility would be enhanced only directly to the south, because of the higher ground immediately east and west (Cloutman and Smith 1988, 55). The inhabitants could have gained a much wider view by walking up the 27 m rise adjacent to the site (Fig. 23.1 bottom), which would raise them above the height of the reedswamp. Attracting game animals to new growth can probably be ruled out. No Name Hill is an island which animals could not reach without swimming; and all four pollen sites are actually *on* settlements inhabited by hunters, not places likely to attract animals. Accidental burning might occur occasionally, but not repeatedly. Access to the lake (Innes *et al.* 2011) is by far the best explanation. Repeated burning of the narrow belt of reed swamp at Star Carr would allow access to the deep-water inlet and the landing of canoes.

Birchbark canoes in Lake Flixton

No unequivocal traces of boats survive from the Early Mesolithic. Discussions are usually limited to the possibilities of dugouts, and skin boats. In this section I will argue that birchbark canoes are more likely than either.

Various dugouts are known from the later Mesolithic. The preferred wood is lime. Mertens (2000, table 7) lists 15 Danish examples, of which all but one are lime. More recently, no fewer than 44 examples have come from the Baltic coast of Germany, of which 43 were lime (Klooss 2015, 181). Lime is relatively soft; experiments have shown that sections can be split and removed from a trunk quite easily with both stone and antler tools (Moses 1987, Christensen *et al.* 1979). Lime was of course not available in the Preboreal – but birch was.

Birchbark canoes are strongly associated with North America, which may be why they are so little discussed in Europe. The preferred species was the paper birch, *Betula papyrifera*, which could reach a height of 30 m and have a basal diameter of 75 cm (Adney and Chappelle 1983, 14). A range of other species was also used, however. To make one canoe usually took several sheets of bark, which were sewn together with spruce root and sealed with spruce gum (Durham 1960). An important point is that bark pieces could be stored in a pool to keep them flexible (Adney and Chapelle 1983, 41; Durham 1960, 30). The Great Lakes fur traders' canoes could be 11m or more in length (Adney and Chapelle 1983, 138), and could carry a dozen voyageurs and 4 tons of goods (Labor 1999). Smaller vessels were more common. River canoes were 4.5–6 m long, and could carry 4–8 people and their gear. Hunting or pack canoes measured 3.3–4.3 m, and could carry up to 4 people and their gear (Cook 2007; Marshall 1986).

Birchbark canoes have a number of virtues. They can access very shallow waterways; they may be poled where the water is not deep enough for paddling, and in the smallest waterways they can be pushed by someone walking alongside (Cook 2007, 30, 62). They are light, and can easily be portaged (carried) by their crew if they have to get round an obstacle (dugout canoes are too heavy to be manhandled by their crews). Lovis and Donahue (2011, fig. 3.10) show a 10 m canoe being portaged by six men. The smaller canoes could be portaged by one person; some portages could be over long distances. Cook (2007, 47) states that 'beaver ... were great allies of canoe people' because beaver dams created waterways in brooks otherwise too small to be navigable – and it was easy to slide a

canoe over a beaver dam.

It is important to stress that in the recent past birchbark canoes were not restricted to North America, but were common across Eurasia from the Baltic to the Pacific (Luukkanen 2010). They are however rarely discussed in the archaeological literature. A major forthcoming volume (Luukkanen and Fitzhugh in press) will go a long way towards redressing this imbalance. Luukkanen (2010, 190) states that ‘the birch bark canoe was the ideal boat for the taiga hunter.’ As in North America, they were often sewn together from several sections of bark, which would be boiled and smoked to be made pliable. They were light and easy to portage. Larch, elm and spruce bark could be used where birch was unavailable.

Birchbark canoes are probably of considerable antiquity in Eurasia. Westerdahl (1985) notes several reports of finds of undated examples. An archaeological bark canoe comes from Byslätt, Västergötland (southern Sweden). It was found in 1934, and comprised a section of elm bark and four ribs (Humbla and von Post 1937). It survived to a length of 3.5 m (Esgeröd 1956). The site is on the River Viskan, near several places likely to require portages. The canoe has recently been directly dated to 980–810 cal BC, the Late Bronze Age (Lindberg 2012).

Did birchbark canoes ply Lake Flixton? Direct evidence is lacking, but various things are suggestive. Clark (1954, fig. 77) identified an elongated wooden object as a paddle. Some caution is sometimes expressed about this – Milner *et al.* (2011, 4) describe it as a ‘possible wooden paddle’ – but various other paddles with similar elongated blades are known from European Mesolithic sites (Mertens 2000, table 8; Klooss 2015, 200–218), so there is no reason to question Clark’s identification. The size range of Preboreal birch trees is not clear; the horizontal example at Star Carr was some 43 cm in diameter. A tree this size has a circumference of 135 cm; several sections this wide could be stitched together into a canoe. Clark (1954, 166) records that ‘numerous tightly wound rolls of birch bark’ were found at Star Carr, the largest 75 × 20 cm. In view of the need to soak bark to keep it pliant (see above) this suggests that sections of bark were deliberately gathered and cached in the lake. This does not prove that it was used for making canoes – it could have been used for roofing shelters, or making containers, and Pitts (1979) suggests that it was a tanning agent used for processing red deer hides. All these are possible, but in view of the ubiquity of birchbark canoes on both sides of the Atlantic in more recent times (see above), canoe construction is perhaps the most likely. Star Carr also produced a resin cake, identified as probably birch resin with an admixture of clay and beeswax (Roberts *et al.* 1998). This would be an ideal sealant for the stitched joins in the bark.

There are numerous other finds of birchbark and birch tar from European Mesolithic sites (Mertens 2000). The most suggestive site is Huseby Klev in Sweden, approximately contemporary to Star Carr. This site was coastal, and the fauna includes many marine species (Hernek and Nordqvist 1995). Boats of some kind are highly likely – and 90 pieces of birch resin have been found. At least 40 have impressions of wood, cord and withies on one side, and in some cases the impressions can be directly identified as birchbark (Nordqvist 2005, 36). It is likely that these derive from the waterproofing of boats (Hernek and Nordqvist 1995, 127–134).

The case for birchbark canoes in Preboreal Lake Flixton is therefore circumstantial but plausible. The next section explores where boatmen from Star Carr might have travelled to.

Star Carr: the upper lake?

In the previous sections I have argued for the logistic export of meat from the Vale of Pickering; the placing of Star Carr at the best canoe landing site in the Vale; the improvement of the canoe landing area by the construction of the plank platform and the repeated burning of the reed belt; and the likely

importance of birchbark canoes.

In this section I examine the wider movements of the hunter-gatherers who visited Lake Flixton. The starting point for this discussion is the central importance of water-based travel and logistic transport. This inevitably directs attention down the canoe artery of the River Derwent, into the lowlying areas of the Vale of York and the Humber estuary (Fig. 23.4).

This focus on the lowlands is the opposite to that normally taken. Clark's own (1972) reconsideration envisaged movement to the uplands in summer. The North York Moors had not been well studied, and Clark was more interested in the Pennines as a possible summer territory, not least because Radley and Mellars (1964) had identified an industry closely similar to that of Star Carr at Warcock Hill South, a considerable distance to the south-west of Star Carr (see Fig. 23.4). Jacobi (1978) also argued for movements to the uplands in the summer, but now the North York Moors played a greater role in the argument, because the industries from Pointed Stone 2 and 3 were very similar to Star Carr. Both Clark (1972) and Jacobi (1978) regarded Star Carr as a winter site. Even after the re-evaluation suggesting spring/summer occupation at Star Carr (Legge and Rowley-Conwy 1988), the uplands have still featured as summer locations (Mellars 1998; Reynier 2004; Donahue and Lovis 2006).

An exception was an effort by the present author (Rowley-Conwy 1995) suggesting that the summer basecamp might be found on the coast, complemented by a winter basecamp at Barry's Island in the Vale of Pickering (see Fig. 23.1 top). This small-scale migration left the upland sites like Pointed Stone and Warcock Hill South unaccounted for. This suggestion has been effectively criticised by Donahue and Lovis (2006) and Uchiyama (2015). Both argue that this scale of movement is simply too small. Remarkably, both propose similar scales of movement, but based on completely different lines of evidence. Donahue and Lovis (2006, 253) suggest likely movements of 50–80 km, based on the ethnography of boreal zone hunter-gatherers in North America. Uchiyama (2015, 9) suggests likely movements of around 60 km, based on the geographical size of typological groupings in Kanto. These criticisms are justified. My original suggestion was based on (a) the hope that the Barry's Island site would turn into a 'winter Star Carr', but this has not happened; and (b) an over-estimation of the importance of the sea shore. The sea stood at about –48 metres at 11,000 cal BP, and –35 metres at 10,000 cal BP (Shennan *et al.* 2012; Ian Shennan pers. comm.), dates which bracket the occupation of Star Carr. Figure 23.4 shows that these shorelines were relatively straight, without the bays, inlets, sounds and islands that created the high-productivity coastal environments exploited in the Late Mesolithic of Denmark or Portugal. Furthermore, the ridge of moraine between the Vale of Pickering and the sea meant that the coast could not be reached by canoe from the Vale. For these reasons I am happy to see my 1995 effort consigned to the spoil dump of archaeological theories.

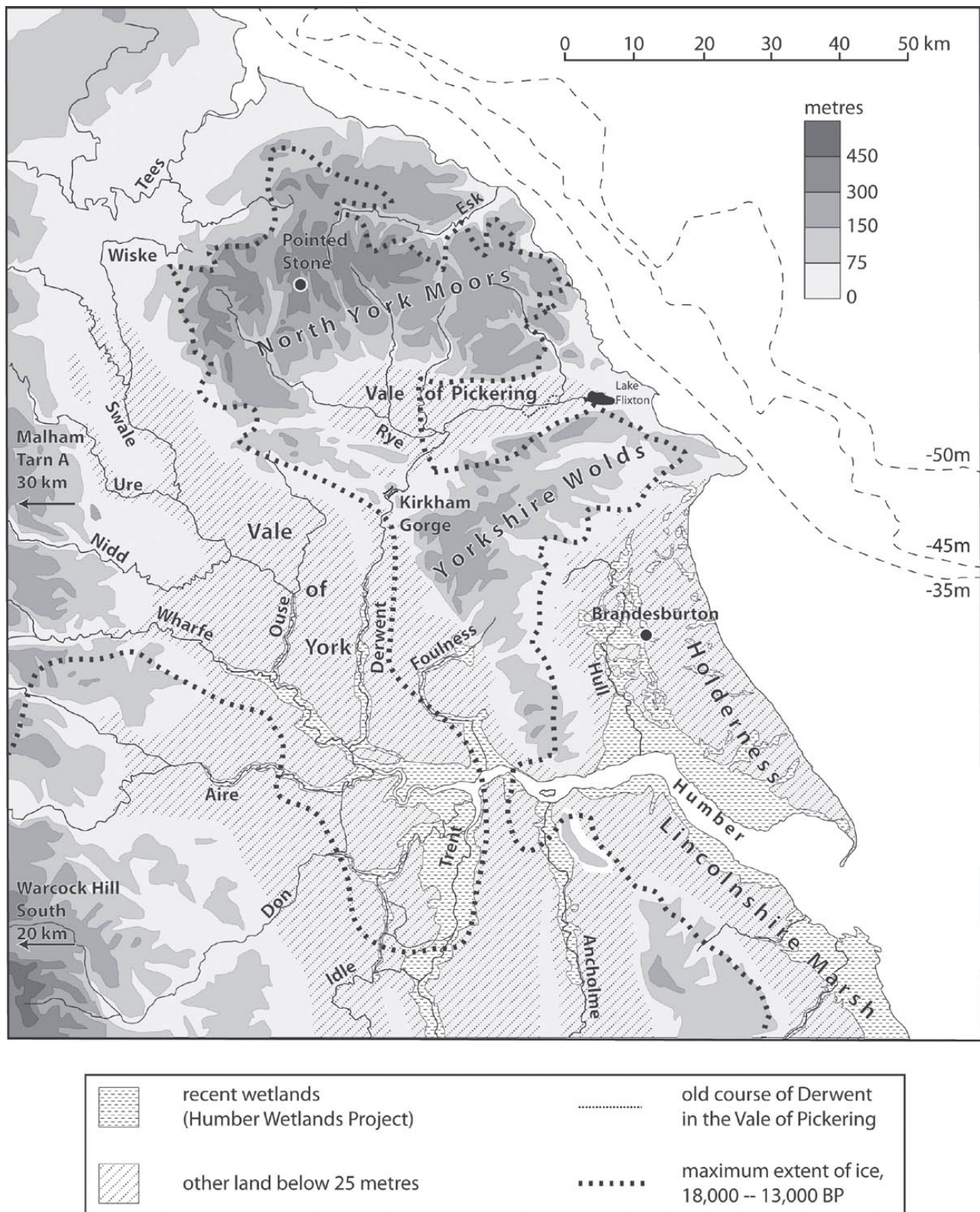


Fig. 23.4. Map of northeastern England. Maximum ice advance from Catt (1990, fig. 2.3). Recent wetlands amalgamated and redrawn from Dinnin and Lillie (1995, fig. 5.1), Lillie and Gearey (1999, fig. 5.1; 2000, fig. 5.1; 2001, fig. 5.1, Lillie and Parkes (1998, fig. 5.1) and Lillie and Weir (1997, fig. 6.1). Lower channels of the Trent, Idle and Don are pre-drainage (from Van de Noort and Davies 1993, fig. 2.8). Old course of the Derwent from Schadla-Hall and Cloutman 1985, fig. 6.1). The sea level was at -48m in 11,000 cal BP, and at -35m in 10,000 cal BP (Shennan et al. 2012, Ian Shennan pers. comm.); these dates bracket the occupation of Star Carr.

The lowlands of the Vale of York and the Humber are rarely discussed at length – the major exception being Uchiyama (2015). The invaluable volumes of the Humber Wetlands Project allow recent wetland areas to be mapped (Fig. 23.4). It must be stressed that some of these wetlands date from the later Holocene, caused by rising sea levels. This goes for those of southern Holderness (Dinnin and Lillie 1995b) and probably the Lincolnshire Marsh (Lillie and Gearey 2001). Elsewhere the situation was different. The meres of Holderness formed in late glacial kettle holes, and remained seasonally or continually flooded until recent times (Dinnin and Lillie 1995a). In the Hull Valley there was considerable Early Holocene fluvial activity and floodplain formation, punctuated by downcutting (Lillie and Gearey 2000). In the main area of the inner Humber and the Vale of York, the retreat of the glacial lobe that filled this area (see Fig. 23.4) left a proglacial lake which had drained by 13,700 BP (Bateman *et al.* 2015). This was followed by extensive areas of late glacial braided channels and aggradation. At some point in the Early Holocene the rivers started to downcut into these sediments. The landscape at this time consisted of migrating river channels and reworked floodplains (Lillie and Weir 1997; Lillie and Gearey 1999). The most useful detailed landscape survey is that by Halkon and Innes (2005), who examined the Foulness Valley (see Fig. 23.4). The early postglacial saw extensive areas of reedswamp wetlands and freshwater systems along the course of the current river; Early Mesolithic deposits comprise a complex mix of peat, estuarine clays, and alluvium (Halkon and Innes 2005, fig. 4). They stress the ‘... complexity of the riverine wetland vegetation units that came into being in this region under the influences of sea-level elevation, alluviation, and water-table fluctuations’ (Halkon and Innes 2005, 231), adding that ‘it seems probable that the wetland environments of the Foulness valley would have provided a centre of resource availability and a focus for human activity’ (Halkon and Innes 2005, 233). Mesolithic flint scatters occur on natural sandy hills.

The inner Humber/Vale of York area was thus probably characterised by incising river courses cutting through areas of sandy elevations, shallow lakes, and poorly drained wetlands. These would probably be unstable and dynamic as the drainage systems sorted themselves out. This might have continued beyond the areas examined by the Humber Wetlands Project – much wider areas are below 25 m in altitude (Fig. 23.4), approximately the level of the surface of Lake Flixton, and would also probably have had areas of seasonal and permanent wetlands. A major study of the Swale and Ure rivers at the upper end of the Vale of York terms these lowlying areas the ‘washlands’, characterised in the early postglacial by numerous waterways, wetlands, and areas of open water (Bridgland *et al.* 2011).

This landscape would be difficult to traverse on foot, but birchbark canoes would provide the ideal means of exploiting and travelling through it, by virtue of their ability to navigate the smallest streams, and being lightweight and easy to portage (see above). The productivity of such wetlands probably made this the main regional centre of Early Mesolithic habitation. Forays out from here could go up the Pennine rivers to sites like Warcock Hill South, or Malham Tarn A (Donahue and Lovis 2006). Sites like Pointed Stone on the North York Moors were accessible via the western part of the Vale of Pickering. Holderness was probably also part of the system – 13 bone points have been recovered from around Brandesburton. There are some differences between these and the large number from Star Carr (Davis-King 1980); none has apparently been directly dated but they are acknowledged to be Early Mesolithic. And forays up the Derwent would bring people to the uppermost lake in this system: Lake Flixton. Ames (2002) states that a one-way journey of 50 km would be easily achievable in one day by canoe. Along the more winding channels that probably characterised the Preboreal rivers, this is about the distance from Lake Flixton to the Kirkham Gorge, which would probably have required a portage; this might have been the site of an overnight camp.

Various aspects of the Lake Flixton archaeological record fall into place when viewed from this

perspective. Early Mesolithic people round the lake used varying quantities of two different types of flint: good quality white flint from the Yorkshire Wolds, and poorer quality material from glacial till. It is assumed that the till flint came from the sea shore because the nodules have pitted cortex (Conneller and Schadla-Hall 2003, 88). However, it seems equally likely that such flint could have come from the glacial till in the Vale of York, the pitting occurring as the incising river channels cut through the underlying glacial moraine. Three caches of flint nodules have been found (plotted in Fig. 23.1 top). These comprise 12, nine and five nodules respectively, and were found tightly grouped (Conneller and Schadla-Hall 2003, fig. 11). These caches would be quite heavy, and quite burdensome to someone on foot – which would be the only way to access the sea shore. But they would be no effort to transport in a canoe travelling through eroding till in the Vale of York. Binford (1979) describes the caching of materials by hunter-gatherers as common; raw materials are usually obtained via ‘embedded procurement’ while carrying out other subsistence tasks, direct trips for obtaining them being rare. This may be why the Vale of Pickering flint caches are of the poorer quality till flint, not the better Wolds material: trips to Lake Flixton passed through areas of till, not over the Wolds.

Conclusion

In the scenario put forward here, Star Carr formed the logistic and industrial hub about which the activities in the Vale of Pickering were articulated with the larger Vale of York/Humber settlement system (see also Uchiyama 2015). The site lay where the river met the lake, and had easy access to open water, which was maintained through the inhabitants laying planks and burning the reeds. Star Carr was a hunting camp, where meat was prepared for onward transport. It was also probably a hunting stand, offering views over much of Lake Flixton. But it was also more than this (Elliott and Milner 2010, 82). Many other activities were carried on. Hides would have been prepared for onward transport (Pitts 1979). Birchbark canoes might have been constructed or repaired. Red deer would not have been carrying antlers in the late spring and summer, so the numerous antlers attached to their pedicels found at Star Carr must have been imported – facilitated by canoe travel. Blanks were produced for point manufacture, but there is no manufacturing debris from actual point manufacture (Elliott and Milner 2010). Were the blanks taken away, perhaps to the upland sites occupied later in the summer, where the points were made and used? Broken points might then be returned to Star Carr and cached in the lake for future reworking. Roe deer would have been carrying antlers during the summer, but most roe killed at Star Carr were juvenile, while the antlers come from adult males and were far more numerous than the other roe deer remains. These too were probably imported as piercing tools of some kind – they fit nicely into the hand and would be useful for a variety of tasks (Legge and Rowley-Conwy 1988). And what were the abraded aurochs distal metapodials (Legge and Rowley-Conwy 1988, fig. 17) used for?

The settlement system proposed here existed only through the Preboreal. Hazel began immigrating at the end of the Star Carr occupation (Dark 1998a, 142). Although hazel would present its own opportunities, the closing of the forest canopy would have reduced grazing potential beneath it. At the same time Lake Flixton was shrinking and the reed belt widening (Mellars 1998, 230–231). This may have been a common pattern across the wider area – Halkon and Innes (2005, 234) note that in the Foulness Valley the close link between Early Mesolithic human activity and the productive aquatic landscapes decreased markedly at this time. The rapid decline of birch at the same time would have reduced the availability of material for building canoes. Elm did not become important until a millennium later, so there may have been a lengthy lacuna in canoe building at this point in the Mesolithic. Hide boats could have been made, but these need drying out every day or two and do not

match the performance and utility of birchbark canoes. After Star Carr, Mesolithic Britain was a very different place so far as its Mesolithic inhabitants were concerned.

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The first farmers in Britain and Ireland – whence and whither and how? Some reflections

Roger Mercer

Introduction

It is a privilege, if a sad one, to pay tribute to a late lamented friend and sparring partner Tony Legge. He embodied a vast experience, seasoned with wide reading, worn lightly. Never one to tolerate fools gladly, Tony could always be relied upon to give an honest, straightforwardly expressed opinion that resounded with common sense and the spice of humour. I recollect with great pleasure our discussions, often concerning the development of the society that engendered Hambledon Hill, that were so rewarding, and offer this contribution in their spirit of pragmatic questioning of the practical issues involved in the performance of actions in evidence in the archaeological record.

My subject will be one that has been much discussed, beginning with Humphrey Case's seminal paper 'Neolithic Explanations' (1969), which has remained without any consensual outcome, largely due to the absence or ambiguity of the available evidence. This paper will seek to look afresh at what new evidence there is. It will also attempt to trace the practical implications for the arrival of the farming way of life in the islands of Britain and Ireland by the observation of experimental enquiry as well as by observing in brief outline later developments in Britain and contemporary events elsewhere. It is an attempt to put some flesh upon the bones of current debate, without straightening the terms of that debate, and in keeping with the limitations of current evidence (Sheridan 2003; Cooney 2007; Cunliffe 2008, 136–138; Whittle *et al.* 2011). It will offer a view of the sources and procedure of the introduction of farming economy to the British and Irish islands.

It is, firstly, necessary to discuss the notion of migration/invasion. Movements of people have often been considered in archaeological studies in a rather simplistic, undifferentiated way, and are only now re-emerging from a period of prolonged disfavour in our view of the spread of material culture and its differentiation. Discussion of the development of thought in relation to migration has been much advanced by the papers brought together by John Chapman and Helena Hamerow (1997). We have come thereby to reconsider the importance of the existence of small groups of élite people, whether socially, technologically or economically distinguished (or, of course, all three) who, on arrival in a new location, proceed, either passively or actively, to invite or compel emulation both materially and perhaps linguistically. They thus emerge in the archaeological record in a strength above that represented by their ethnic numbers. Such an interpretation is now accepted widely for the

Anglo-Saxon invasion/migration into Britain which testifies to the impact that the small-scale ‘seeding’ of an alien population can have upon archaeological outcomes (see Hamerow 1997, 33–34).

The prevailing alternative views of the nature of the advent of farming practice to Britain and Ireland are (almost certainly simplistically) drawn: the ‘native’ vision of its osmotic induction by ‘acculturation’ by and within the existing foraging population versus the ‘immigrant’ version consisting of the physical introduction of the materials, skills and thought processes of farming by immigrant people originating on the continent of Europe. The controversy has its roots in the paper published by Graham Clark (1966) – a controversialist work aimed principally at his contemporaries. In this Clark set his target high in order to get a better shot at it. It is a misfortune of the English language that expressions such as ‘invasion’, ‘migration’ and ‘colonisation’ bring whole boat-loads of historical baggage with them, certainly to scholars of Clark’s generation. They almost always contain connotations of size, intensity and organisational complexity which may be completely irrelevant in the historic or prehistoric context. It was only three years later that Case produced his paper on ‘Neolithic Explanations’ in which he cut across the controversy that Clark raised by setting out the inescapable foundation of the material that was related to the introduction of farming. Whatever the *modus operandi* of the introduction of farming, plant materials and animals with no natural forebears in Britain and Ireland were brought here, by sea, with the attendant practical difficulties that will be examined below. The polar extremities of this debate are perhaps best represented by the work of Julian Thomas (1999; 2007) who has championed the acculturative case and Alison Sheridan (2003; 2010) who favours the immigrant basis for the changes. This is a necessary discussion because, whatever view is taken of the introduction of farming to Britain, there has to be an element of human interaction in the way that animals (sheep and goats) and grasses (wheat and barley) that were non-native to these islands were brought here. Case (1969, 176–178) reminded us of this, but he lacked one element in support of his argument.

In Britain’s case the Mesolithic population was, in archaeological terms, a remarkably chronologically confined group, of relatively small size, that arrived in Britain after the last Glacial maximum during which time the great majority of the land that now makes up Britain could not be occupied. Residence by this group was thus effectively confined to a period less than eight thousand years (300+ generations based on the customary 25 years).

One of the great difficulties that faces us in the assessment of the Mesolithic contribution to the interaction is any clear conception of the size of the population of late forager/hunters in Britain. Rowley-Conwy (1986, 24) has indicated that ‘the presence of a larger ungulate biomass, and the increased availability of plant foods are ... factors likely to ensure an *increase* of population in the Mesolithic’ (author’s emphasis). Smith (1992) has suggested that the population of the island of Britain at around 6000 BC was, on the basis of ethnographic parallels elsewhere in the temperate zone, probably 2500–5000 souls. This tiny number might have been expected to have grown by the end of the fifth millennium. A decline in marine resources and the over-hunting of ungulates have been suggested as possible reasons why certainly dated Mesolithic deposits seem to decline in numbers after c. 5000 BC.

The impact on such a population of even a small number of newcomers can be indicated by a simple and crude calculation that shows that two families of two adults and five children can produce, within 12 generations (i.e. notionally 300 years), approximately a quarter of a million descendants, if all the families produced five children. This is, of course, purely notional – human descent is not a mechanical process. Distorting influences of many kinds interfere with a population and its demography at any stage of its development from individual tragedy to widespread catastrophe of biologically epidemic, physically destructive or other origins. Nevertheless the point is made that a

comparatively few – say a few hundred – brave, perhaps desperate, souls arriving on the shores of Britain in the forty-second century BC or earlier could have engendered a population in the hundreds of thousands. This figure would not be implausible in the context of the known archaeology of Britain by 3800 BC. It is also important to remember that the process is, of course, hyperbolically cumulative – the notional two families will have engendered only 2,500 descendants by generation eight, i.e. after 200 years, with any setbacks before that point all the more proportionally devastating.

Alan Barnard (2007), on the basis of ethnographic observation of foragers and former foragers in southern Africa, has reviewed the modes of thought that are characteristic of forager and farming societies. The quite radical contrasts that are likely to have existed between the two populations include: concepts of kinship, the association with the land, social hierarchy and the accumulation of consumables. Foragers can successfully integrate with farming communities, particularly on a seasonal basis. However there remains some doubt about the degree, intensity and length of interaction that would lead to a unilateral move to farming by a forager community, such are the massive psycho-cultural obstacles to be overcome. Such doubts make it difficult to picture the first step in this process being taken by a forager foot. In terms of the scenario of sea-transit (discussed later), the introduction of animals by migrants, rather than the collection of animals by foragers seems altogether more likely. The intermarriage of immigrant (perhaps predominantly male) with native forager may well be a likely vehicle for the accomplishment of that transaction.

This must raise the question of the archaeological detectability of this population during its earliest manifestation. It is always difficult to postulate the existence of small populations, otherwise undocumented, and then to suggest that their impact is too feeble to have been registered in the proxy record. Nevertheless if small and temporary clearings in areas that had already been partly cleared by agents such as windfall or beaver activity were made to allow small numbers of animals to graze in order to create a seed-bed, they are most unlikely to figure in pollen diagrams from the sediment of a lake a mile away. An object lesson is available for us here in the *Liber de Mensura Orbis Terrae* where the author, the monk Dicuil, records the presence in Thule (Iceland?) of ‘papar’, hermetical monks, who were settled there some thirty years before AD 825. By the time the Norse arrived in 874 these exiles may have gone, but Christian symbols were recently discovered carved at Kverkarhellir Cave, sealed beneath volcanic ash dated to 871. This has added some credibility to Dicuil’s account yet, despite ardent enquiry, no proxy evidence of an environmental nature yet exists of the presence of the monks.

Marine conditions

The islands of Britain and Ireland stand in waters of considerable turbulence, both wind and tide driven. They are isolated from the continental land mass on their east and south by seas of very different calibre and are faced by coasts of a widely contrasting nature from the Skagerrak to Ushant. To the south, the English Channel had resulted from a breach of the chalk link to the continent that must have occurred between 6500–5400 BC. Full marine conditions prevailed in the southern bight of the North Sea from some time between 5800 and 3800 BC (Coles 1998, 67). Prior to this, obstacles existed to the free flow of water from the Channel. During this period step-changes and variations may well have occurred with quite unpredictable suddenness and violence. By 6000 BC the southern part of the North Sea was a complex and shifting pattern of islands with channels that could become violent tidal races as water flowed and ebbed from the deeper water to the south. This would have been a highly unpredictable environment, full of danger to the small boat sailor at all seasons (Garrow and Sturt 2011). Throughout this period the present day Channel would have been narrower and very

actively eroding. This would have created difficult landfalls for the sailor as there would have been little accumulation of alluvial or marine deposited beaches in embayments. Such exposed landing sites with the relatively fragile structures of first settlers would be very difficult to recognise archaeologically, even if they were retrievable.

The period 5400–4500 BC was some 1–2°C warmer than the century prior to AD 1950 and has been referred to as the ‘Atlantic Maximum’. Its impact was to bring about the access of melt-water that caused the onset of the sea-level rise referred to above. It must also have created a major break-up of the floes in the North Atlantic which, in turn, led to fleets of icebergs appearing as far south as the Irish Atlantic seaboard, as witnessed by melt-out rocks deposited in ocean silts there at about 4350 BC (Tipping 2012 and references). The access of cold water to the North Atlantic has been suggested as a cause of movements of fishing grounds and changes to the seasonal shoaling movements of fish. This may in turn be linked to the dietary trends away from fish consumption in coastal communities, as indicated by isotopic analysis (Schulting and Richards 2002), a view that is now however being challenged (Janet Montgomery pers. comm.). Concurrent with this warming phase was an augmentation in the frequency and strength of the westerly winds that dominate the seas of the entire area. Greater storminess seems to have characterised the weather patterns of the NW European littoral area which, in turn, led to accelerated dune formation on coastal forelands after about 4000–3800 BC (Tipping *et al.* 2012, 11). From c. 4600 BC for about 400 years, i.e. precisely during the period of the transition to agriculture, the average temperature in the northern hemisphere cooled, with winter temperatures sensibly lower. This changed in about 4250 BC with the temperature ameliorating until after c. 3800 BC when greater aridity became general.

Boats

It has been suggested (Dennell 1983, 185) that the sea-faring tradition on the Atlantic coast must have been a Mesolithic tradition, emphasised by his memorable phrase that continental farming communities ‘would have had as little reason to take up seafaring as the Swiss Navy had to invent the battleship.’ The precise format of that boat technology has been, and remains a challenge to our understanding. David Peacock *et al.* (2009) were stimulated to consider boat technology by a very substantial fragment of a broken puddingstone quern weighing 16 kg that was located during the 1934–1937 excavations at Maiden Castle, Dorset, sealed in a Neolithic pit (pit 9 on Site T) (Wheeler 1943, 322, fig. 112, 2a–c). The stone is described as silicified flint conglomerate and was identified by Peacock *et al.* as originating on the plateau of St André de l’Eure, 10 km south of Evreux in Normandy. This prompted enquiry as to how such a substantial object came to travel the 320 km, of which at least 225 km was by sea, at such an early period.

The carriage of such a substantial object caused a review of the use of skin boats, as preferred by Case, in favour of log-boats. Some evidence does exist in support of these in NW Europe. In Czech Republic expeditions of 1995 a log boat stabilised with outriggers with 9–11 paddlers plus passengers and an unspecified payload was paddled for 300 km among the Aegean islands during a crossing of the Aegean (Tichy 2002). In 1998 the boat was paddled in stages from Sicily to Portiragnes on the south coast of France carrying 100 kg of stone and water. During this voyage the crew encountered 2 m high waves and winds of Force 7–9 on the Beaufort scale. In the English Channel equivalent wind-speeds can be encountered in mid-summer but, significantly, wave heights can easily double those encountered in the Mediterranean.

The objections to the use of log boats, whether outriggered, paired or not, are, however, overwhelming to this writer while the virtues of the umiak-type skin boat are equally convincing. From

the point of launch to the point of unloading the skin boat is easier to handle and a more comfortable vessel. Only a skin boat could be launched by its own crew at any stage and in any degree of swell – certainly so if in cargo. Equally only a skin boat could be pulled clear of the water by an (exhausted) crew and overturned to offer an immediate shelter. Furthermore while at sea only the skin boat could offer the degree of freeboard necessary to protect the paddler and his or her precious cargo of animals from exposure to wind, chill and spray – to all of which young animals are very vulnerable.

The only alternative to a skin-covered hull construction or a hollowed-out log boat in the ethnological and archaeological record in northern Europe is the plank-built boat. This has sewn jointing, usually carried out with withies, with joints caulked with moss or other suitable agents. Examples of such boats are well known from the Ferriby sites in East Yorkshire, from Dover in Kent and from sites at Caldicot in Glamorganshire. Two objections present themselves to the availability of plank boats during the Neolithic period. The first is intuitively the same as that raised by Piggott with reference to wheeled vehicles: that the intricacy of cleat cutting and other refinements of sewn wooden boat structure would have required the possession of a metal gouge/chisel/awl tool that only became available in the Bronze Age (Piggott 1983, 20–21). Secondly, the great weight of plank boats would have severely limited their manoeuvrability when not afloat. The Dover boat and the Ferriby F1 boat are approximately 16.5 m (16.3 m and 17.0 m) long. The suggested crew for Ferriby F1 was 20: 18 paddlers, a helmsman and a captain (de Noort 2006, 280). Ferriby F1 weighs 3.8 tonnes (dry) with paddles, etc., making an overall weight c. 4 tonnes unladen (Wright 1990, 113). If the whole crew are active, each person would be committed to lifting/dragging a fifth of a ton into or out of the water.

Because of their great weight, plank boats of Bronze Age type must have required a designed destination, a staithe or jetty of some kind in a tidal creek which would allow the sea to do the ‘heavy lifting’, but which would be sheltered from surf or high wind. Van de Noort records that the remains of the sewn plank boat at Caldicote was located in close proximity to (an admittedly later) structure of bridge/jetty type, set in a tidal inlet. Such a vessel would have been fundamentally unsuitable for adventurous forays and beachings upon an unfamiliar coast.

When Case was writing in 1969 he had little knowledge of the performance of skin boats in northern seas but, thanks to the enterprise of Tim Severin (1978), that *lacuna* has been, to some extent at least, filled. The largest umiak in the ethnographic record was c. 18 m in length, which must be close to the threshold of the fabric and design in a sea-going context. The *Brendan* was 36 ft (11.08 m) in length and 8 ft (2.8 m) in the beam. It was equipped with a square sail, but that may or may not have featured in any Neolithic boat. The *Brendan* was built on a frame of ash batons $2 \times 5/8$ in (0.05×0.016 m) with stringers in ash $2\frac{1}{2} \times 5/8$ in (0.06×0.016 m). The oak gunwales were furnished by lengths of 1×6 in (0.024×0.13 m). The strength and flexibility of such timbers could readily be furnished by coppiced saplings and late growth. Joints were fastened by leather thongs inboard of the hull ‘skin’. The hull of the *Brendan* was made up of cattle hides and to render them waterproof they were tanned in oak bark and impregnated in a bath of sheep wool grease at a temperature of 50°C, arriving at a take-up of 30–37% of grease by weight.

Forty-nine ‘butts’ (cattle-hides without the legs) were used in covering the hull of the *Brendan*, and further hides may have been necessary to replace the tarpaulins to cover the fore and after deck. The hides were sewn together with flax (*Linum usitatissimum*) thread. Flax itself was available on both sides of the Channel during the Neolithic but flax thread presumably could have been substituted by thongs or sinew. For the sail, if such a feature existed in the Neolithic, the first issue is the material used in its manufacture. The *Brendan* sail was manufactured from flax linen. Though flax was available, its use, whether as a source of oil or of fibre, is uncertain and there is no evidence from the Swiss sites where linen has survived that it was produced in lengths and widths that would be useful to a sail

maker.

In the circumpolar context seal skins were used for skin boat construction and blubber for the waterproofing and it is possible that these were used in the Neolithic. Based upon the 250–280 kg weight of the adult bull seal and its length of 3 m one might conjecture that two to three times more seal hides would have been required than ox hides. The only snag would be the enhanced capacity for leakage due to longer seaming. Such numbers of grey seals (*Halichoerus grypus*) would have been available from colonies on the Ile-Molène, Mont St Michel or others in the Rhine Delta, such as at Terschelling and along the northern Dutch coast (Gerondeau *et al.* 2007). Seals haul out in the autumn on small uninhabited islands where their pups are born and it is at this time that they are most vulnerable to predation. Their pursuit would have the double benefit of obtaining the pelts and eliminating their impact on flat-fish and molluscs, their favourite diet.

The only ‘counter-Neolithic’ element of the *Brendan*’s construction was the attachment of the keel-skid, which is an essential aid to beaching and launching without extensive damage. This was attached to the frame of the *Brendan* by copper nails, heads flattened to prevent leakage at the point of skin penetration. It would have been possible to add a skid to a Neolithic boat. It would have extended beyond bow and stern (as shown in many Baltic rock-face carvings) and tied to each gunwale by a vertical lashing encircling the hull. This might explain the vertical strokes seen on the hull outline of some the Scandinavian rock-cut images. An extension beyond the bow and stem might then have been roped horizontally to prevent ‘hogging’, which would perhaps be necessary in a boat any longer than the *Brendan*.

Resources and payload

The resources necessary to construct such a craft are immediately apparent: more than 50 cattle hides (or 100–150+ sealskins?), 4–5 km length of thongs made of leather, and timber in particular but perhaps not in remarkable quantities. These were substantial resources to commit to a high risk project where every doubt would remain in the minds of those left ashore as to whether they would ever see the vessel or its crew again. As importantly, it is hardly likely that these could have been secret preparations and surreptitious departures, and there is some likelihood that they were near-universally sanctioned. If nothing else, the acting of loading a boat and launching it from the beach into the surf – for this is the true home of the temperate zone skin boat – must have been to some extent a public event.

The ‘pay-load’ of *Brendan* is difficult to assess. The voyage was undertaken with a crew whose modern ‘Spartan’ requirements may well have been more than matched by those of their prehistoric forebears. The *Brendan* crew bore with them anachronistic equipment – an emergency raft, wireless communication, first aid, etc – that it would have been criminally irresponsible to set aside. The boat carried 726 kg of fresh water as ballast. There was a relatively small assemblage of electronic, battery, emergency and pumping equipment in addition to the personal stowage and rations whose weight was not given in Severin’s account, but which are estimated by this writer to have been little short of 100 kg. As some water and stowage would have to have been carried by Neolithic forerunners, it can be suggested that, to achieve the same buoyancy and stability as the *Brendan*, it would have been possible to embark a payload of c. 650 kg as well as a crew of five, as was carried on the *Brendan*. Such a payload might have included two 4-month old calves (c. 360 kg?), two 4-month old lambs (c. 40 kg?), two 4-month old pigs (c. 140 kg?), and seed corn (50 kg?). Such a cargo would have to have been immobilised by hog-tying and, vulnerable as such young animals are, protected and given regular attention. Forage and fresh water, weighing about 100 kg, would also have been necessary for their

sustenance on the voyage.

The deadweight of the *Brendan*, without sail or oars, was estimated at 1088 kg. With payload, stores, and seawater uptake into her hide hull she might weigh 4.5 tonnes. It would have been important for a Neolithic boat to carry 6–8 short baulks of timber, ready greased, to facilitate pulling her clear of the surf on a gently sloping even beach after the boat was unloaded her. The choice of such a land-fall would have been very important and fortunately the coasts of south-west and southern England and the south and indented east and west Irish coasts are well supplied with such sloping beaches. Callaghan and Scarre (2009) advanced these issues by a computer simulation. Their figures bear a very close resemblance to those calculated by this writer.

Constraints of tide and currents

The recorded performance registered by Severin (1978, table v) suggests that a mean rowing speed for six crew with a fully loaded boat was 3 miles per hour (c. 4.8 km), let us say 64 km per day in optimum circumstances. Brest and Cork are separated by 450 km of open sea, i.e. 7 days sailing, which is comparable with the Callaghan and Scarre estimate of 8 days. In such an order of time hard-rowing men and the animals would have consumed a great quantity of water. This writer suggests 5 litres for each animal so our notional complement of six animals over 8 days would need 240 litres. Each man would require, say, 5 litres per day, so six men would also require 240 litres for a trip over 8 days. Such a quantity would impact severely on the payload, as would the question of fodder. This quantity is so great that it renders the equation self-cancelling.

A more likely voyage is from Brittany deflected by the wind, tide and current to the north-east to arrive on the south coast of Britain. From Brest to, say, Plymouth or Torbay, is a distance of approximately 250 km, say 3 days sailing. This might even be reduced in favourable circumstances of up-channel winds and tides and if so the chance of survival with viable animals would have been much enhanced. From Le Havre at the mouth of the Seine the distance to the English mainland is 150 km or 250 km to Dover which is a more likely destination taking account of the Channel current. A boat starting north of Le Havre would enter the mouth of the Channel with a considerable chance of passage north to the Thames estuary and the Essex coast.

The Channel is so situated that the surge of tidal water coming from the Atlantic Ocean encounters the obstacle of Ireland and Britain and divides to pass on both sides. The northern stream fills the North Sea basin via the Pentland Firth, while the southern influx fills the Channel and its approaches. The complex outcome is that when the initial tidal influx into the Channel is receding the mass of tidal water that has raised the level of the North Sea after its passage around the north of Scotland constitutes a second tidal thrust into the Channel from the north, or vice versa. The consequence is that the Channel is subject to two irregular tides per day and has a consequent *farrago* of cross currents, undertows, rips and races. It can, for example be simultaneously high tide at Portland and low tide at St Catherine's Point on the south coast of the Isle of Wight. There is double tide-water at Southampton and Poole, and Portsmouth rejoices in two flood-tides and two high waters, during which time the sea level remains constant with only one short period of low water – which is why, since 1400, it has been England's principal naval base.

The upshot is that estimating the course and duration of a channel crossing in any small boat was always likely to be difficult, especially when its other characteristics are taken into account, its liability to highly changeable weather and the rapid onset of high seas, that make the Channel one of the most dangerous confined waters in the world.

It is difficult to arrive at a picture of the experience of crossing the Channel in an open, paddled,

skin-covered boat. There do exist, however, very accurate and consistent records of the passage of Channel swimmers. Such attempts always start from the vicinity of Dover and aim to come ashore at Cap Gris-Nez. The course of the swimmers follows a remarkably replicated V-shaped course which is dictated by the double tide ebbing and flowing every six hours. This compels almost all swimmers to swim due east with the up-Channel tide and then turn south with the down-Channel tide. It means that nearly all Channel swims are of 45 km or more. It is very likely that a paddled skin boat would have been governed by similar considerations. Being compelled to run with the tide, a boat would have found that the journey time for the 45 km between the Pas de Calais and Dover, at 3 miles per hour (see above), would have taken more than 9 hours. It would also only have been possible in summer. Further west, the times taken may have had their 'point to point' distances increased by 20–30% due to tide or weather. On occasion, of course, fog or mist would also have been encountered. From the coast of Normandy to the nearest landfall in Britain is 216 km. This would be a long voyage of approaching 48 hours involving two nights at sea – if all went well.

A number of probable conclusions arise from this survey.

1. That the first farmer immigrants to the Britain and Ireland could not have been, by any means, inexperienced navigators. To make even the direct line of sight crossing from Calais to Dover in days of clear fair weather (in the Channel, *rara aves* indeed) would have required considerable inherited and acquired skills. It also would require considerable resilience and strength.
2. That the freeboard and hull capacity available in any log boat would be insufficient to allow such navigation. It has also been argued here that a sewn plank boat of Ferriby/Dover type would have been less suited to an unprepared beaching and unduly difficult to handle in such circumstances.
3. That, whether undertaken in skin or sewn wooden boats, the crossing could only have been accomplished by a small human crew or a group of such crews, plus tethered animals and basic supplies.
4. After the first contact, that it is likely that future settlers would seek to arrive at particular points, assisted by material landmarks/sea-marks, and that there may have been 'pilots' to assist for repeat voyages. A basic knowledge of the cardinal directional significance of celestial indicators is likely needed for any voyage of over 50 miles (80 km). For instance, a voyage from Normandy to Sussex would have involved an extended period without sight of land and a period of navigation during hours of darkness.
5. That such voyages could not have been contemplated if they had been expected to last more than 3–4 days as the impact of time, exposure, wetness and salt upon humans, young animals and vegetable contents of the vessels would have seriously affected their welfare and viability.
6. The direct voyage from Brittany to Ireland, at 480 km, would have been at least a 5 day voyage and possibly longer. It is unlikely that such a direct voyage with 7–8 days fodder and water for animals would have been either practicable or successful. This broadly expressed restriction would have rendered it impossible for Neolithic boats to undertake the voyage direct to Ireland. The currents of the Western Approaches would have favoured a land-fall on the (greatly larger) Scilly or on the north coast of Cornwall. Thus settlement in Ireland would have required familiarity with south-west England and probably south Wales as a stage for rest and recuperation.

Cross-channel cultural links

There has been, since the mid-1980s, a trend, led by the late Marek Zvelebil and Peter Rowley-Conwy, to compare the introduction of farming to Britain with the development of similar cultural stages elsewhere in northern Europe (Zvelebil and Rowley Conwy 1984; 1986). While such a comparison is valuable, it may be as instructive in pointing up contrast as in suggesting points of similarity. Indeed Zvelebil and Rowley Conwy recognised (1986, 75) at the outset that the 'British situation is thus, still rather confused'. That confusion, it seems to this writer, still persists.

Uniquely, the migration of agriculture to Britain involved a long over-sea transfer, following preliminary exploration. That must have severely limited the opportunities for any process of gradual and consistent familiarisation – on either side. It is possible, as Thomas (1988, 60) has suggested, that forager/fisher communities became familiar with farming in the course of purposeful or accidental visits from Britain and Ireland to trans-Channel shores. Such contacts, however, can only ever have been occasional and, were possibly not socially or economically interactive to any great degree. There is no material evidence for such interaction in the form of imports of Neolithic material from the Continent into Britain in a pre-Neolithic context. Conversely, it is also unlikely that any diagnostically British object could be recognised in an early Neolithic context on the continental Channel or North Sea coast. This was a severe limitation on the likelihood of finding any trace of the casual or neighbourly relationship that is so readily available in continental contexts. There, the interacting over the control or killing of animals, the control of predation on crops as well as the trade in commodities such as pelts on one side and objects of a foreign and exotic nature on the other have created an archaeologically visible spectrum of interaction, adjustment and influence as was so neatly summarised by Zvelebil and Rowley Conwy. They defined stages in the adoption of farming: a phase of *availability*, in northern Europe followed by a phase of *substitution* by slow 'osmotic' processes, and, thence, consolidation. In the case of Britain these three stages must have been compressed into one process of acceptance/toleration or rejection/intolerance on a relatively short, if not first, acquaintance. The kind of acculturation that is visible between the Rössen culture and Swifterbant or Ertebølle would have been impossible in the context of Britain, either for taphonomic reasons, notably sea level change, or on the basis of the social and practical realities of the period.

At no other stage in the prehistory of Europe can this interaction have been so abrupt and so radical, whether to foragers or farmers. Even during the long process of Impressed Ware expansion along the Central and Western Mediterranean and then along the Atlantic coasts of Iberia and France, the transfer of tradition could have been accomplished by short 'tramping' advances along the coastline. Over-sea voyages were required to Sardinia, Corsica, and the Balearic, Aeolian and other isolated islands but these were in an inland sea where tides were restricted and, given an astute observation of the season, relatively friendly waters could be more or less relied upon. The peripheral, impoverished nature of the Tyrrhenian Mesolithic may help to explain the relatively straightforward, limited availability – substitution phase on the islands prior to the rapid ascendancy of Cardial sheep-farming (Lewthwaite 1986).

During the relatively narrow time frame between 4500 and 4000 BC, an astonishing range of cultural, technological and social attainment and organisation was present in the societies, which were the immediate neighbours of Britain facing southern England, southern Ireland and eastern England across the North Sea, the Channel and the Western Approaches. All varied widely in their habitat and economy.

Low Countries

In the Rhine Meuse/Waal/Ijssel delta area a highly complex and variegated cultural situation existed by 4400 BC (Verhart 2008). The rises in sea level referred to above were actively and recognisably changing the estuarine circumstances that surrounded native foragers, while social and economic influences were exerted by neighbouring farming communities. The forager/farmers emerging from these processes before 4800 BC such as the Swifterbant culture were challenged by multiple pressures. This group was familiar with Rössen farmers in the northern Rhineland who were succeeded in the uplands to the south of the delta by the Michelsberg (MK) culture that emerged after 4500 BC in the northern Rhineland. In its middle stages of development (c. 4000 BC) its characteristic house type (from a relatively few known settlement sites) changed from the longer, often trapezoid, form that it inherited from Rössen antecedents to a shorter rectangular form. It was such a form that appeared in the earliest Neolithic in Britain. Other links with MK are very general. Parallels with its characteristic pottery are highly selective and often unconvincing, although less so with the marginal Belgian Group as defined by Scollar (1959). The distinctive lithic types of the British Neolithic, notably the leaf arrowhead, are only patchily available, and seldom closely similar to anywhere on continent. The exchange networks linked to MK tend not to be carried into Britain other than in the case of jadeitite implements (see below). Causewayed enclosures occur in association with MK cultural material, although seldom in the coastal foreland of Belgium and northern France. Flint mining is another distinctive activity associated with MK/Chasséen culture in Belgium, Limburg and northern France. There, it was conducted using a wide variety of techniques, depending upon the local qualities of the raw material and those of its matrix. Narrow-shaft mining tended to dominate the Belgian/Dutch mining process while a far greater variety of extraction techniques appeared in Picardy. The dating of prehistoric mining has never been straightforward – mine complexes may be returned to many times – and a few dates from a very limited number of contexts may not give any true idea of the span of the site. However, at Mesvin ‘Sans pareil’, Hainaut a sequence of radiocarbon dates suggest a bracket 4200–3960 cal BC (Hubert 1980) while the mines at Rijkholt St Geertruid, Limburg range between 3940–3750 cal BC (de Grooth 2005). The greater variety of approach that occurs further south in Picardy, Seine Maritime and Oise provides the closest parallels to British mining. There, the flint mine complexes such as at Jablines, Seine et Marne, and Ri et Ronay, Orne (Giligny *et al.* 2012) produced compact groups of dates between 4300–3800 BC. Similar flint extraction took place in southern England, notably Sussex, at an early date in the Neolithic, probably beginning shortly prior to 4000 BC and proceeding until at least 3500 BC (Barber *et al.* 1999, 2).

Further north than the Rhine delta there appears to be very little indication of contact with Britain in the early Neolithic. There are minimal exceptions. Childe (1932) published a group of sherds that were recovered some time between 1881 and 1883 from a midden among sand dunes between West Hartlepool and Seaton Carew, Cleveland (now in the Museum of the Society of Antiquaries of Newcastle) of Funnel Necked beaker (TRB) pottery. The sherds appear to be close to the Fuchsberg and Svaleklint style in Denmark and, possibly, the Brindley Horizons 1–3 in the Netherlands, a horizon that would now be dated to the junction of the South Scandinavian Early and Middle Neolithic (ENII–MNIB), i.e. from about 3500 BC onwards. This coincides with the earliest phases of the causewayed enclosures at Sarup by Hoorby, Fyn, and Toftum, east Jutland, Denmark (Anderson 1997; Madsen 1978). Such pottery occurs in the Low Countries at the NW extent of its Rhenish distribution where it is regarded as later than MK style (van Gijn and Louwe Kooijmans 2005, 333). The fabric of the pottery from Hartlepool is quite distinct from contemporary British Neolithic wares and is consistent with wares found on the eastern side of the North Sea. There is very little possibility that these finds are lost collector’s items or otherwise than from an authentic context.

A number of very finely-ground square-butted polished flint axes executed upon flint that is naturally endowed with banded integral colouring have been found (Sheridan 1992, 209; Saville 1999; 2004). The absence of an origin for this type of flint in Britain and their (almost) exclusive distribution along the east coast makes it difficult to resist their attribution to a Baltic origin. But these contacts must be late in comparison with those suggested with the Low Countries with the possibility of links to north Holland/Jutland occurring sometime about 3500 BC, by which time the insular early Neolithic had reached its zenith.

France

However a farming culture had been present in Normandy and on the French coast as far north as the River Somme since the arrival of Late LBK in the area. At the site of Cerny, Essonne radiocarbon dates cluster around 4300–4650 cal BC and at Villeneuve St Germain, Aisne perhaps a little earlier, between 4900–4600 cal BC. These dates suggest awareness of farming practice and ideas on the coastal foreland of what is now northern France at least 200–300 years before the likely date of any transfer of population to the British and Irish Islands. This area is a primary source for the development of the northern French Chasséen which in itself displays a strong relationship to the MK discussed above. Causewayed enclosures exist in numbers along the valleys of northern France and, since the preceding Cerny phase, were associated with linear monuments, as at Balloy, Seine et Marne (Midgley 2005). They exhibit parallels, however general, with long barrows and long mortuary enclosures in Britain. The pottery of the Chasséen, shows a basis for the development of much that appears in British ceramics as the Neolithic develops and, to this writer, the material culture of this zone, the Somme-Seine valleys from the Pas de Calais to the Ile-de-France and the Champagne, forms the most all-embracing source of many of the cultural features that characterise the early Neolithic of southern Britain. The coastline from Le Havre northwards to Calais comprises the most natural spring-board for the occupation of the English shore as far north as Essex.

However, for the variation that is also the *leitmotif* of these trans-Channel transfers, we are thrown back upon Case's argument (1969) that the cause was the traumatic social and psychological disorientation of the crossing. This may have been further developed by a gender imbalance among the migrating population thus altering the basis of cultural content as observed in the archaeological record such as the absence and/or radical changes in pottery manufacture. Any such gender imbalance may well have contributed to the strong surviving genetic signal noted by Oppenheimer (2006) for the Mesolithic population.

Further west, in the Norman and Breton maritime zone, a distinctive cultural development based upon a unique combination of southern and central European Neolithic impulses and a Mesolithic population enjoying a measure of coastal stability had been established early in the fifth millennium. This amalgam saw the development of a complex social hierarchy that exercised considerable power within the local population where large numbers were diverted to vast engineering works of a type hitherto unknown in Europe. This programme extended its influence in a manner that allowed it to attract contact and prestige over a wide area of western Europe (Pétrequin *et al.* 2012; Scarre 2011). Sheridan (2003; 2010) has argued that the dramatic development of the Neolithic in Brittany, its extension to the Channel Islands by 4500 BC, and the emergence of the quite extraordinary flowering of this hierarchy, led directly to a migration of people to Britain. This is not the place to reiterate Sheridan's meticulous examination of the likely background in Brittany and Normandy for some British and Irish ceramic developments and passage grave architecture in the early fourth millennium.

Brittany can also offer support for the enclosure tradition. Currently the existence of Neolithic

enclosures in the western parts of Britain and Ireland and around the Irish Sea is only relatively rarely recognised, but Scarre (2001) has brought to our attention two examples of enclosures sited between Nantes and the Carnac area. The site at Sandun is set on a low promontory on the edge of a salt water marsh on the Atlantic coast by the mouth of the Loire, 60 km WNW of Nantes. In its second phase of occupation the site appears to be at least partly defined by a ditch 4.5 m wide and 1.5 m deep with a palisade trench set on its interior side. If the enclosure occupied the whole of the natural eminence upon which it stood it would have had an extent of some 6 ha. The interior featured a number of pits with Chasséen/Carn style pottery. The enclosure phase is associated with radiocarbon dates of 3950–3350 cal BC (Gif 7701) and 4050–3700 cal BC (Gif 7702) (Scarre 2001). Other sites were indicated by the late Andrew Sherratt (1998). It is clear that in the absence of excavations numerous drystone-walled enclosures located on promontories, occasionally joining outcrops of natural rock, may relate to, or conceal beneath their structures, early-middle Neolithic deposits and structures. One such enclosure is that at Le Lizo, a complex multi-period site built around a passage grave of *allée coucée* type. Parallels for such walled enclosures may exist in the Neolithic settlement enclosures located in Cornwall at Carn Brea (Mercer 1981) and Helman Tor (Mercer 1986) and in Pembrokeshire at Clegyr Boia (Williams 1953).

Chronology

The chronological framework of the early farming transfer to Britain has recently been massively reinforced by the AHRC funded *Gathering Time* project of multiple radiocarbon dating given greater precision by Bayesian amalgamation (Whittle *et al.* 2011). The resultant chronology has encountered a range of difficulties related to regional deficiencies of evidence. Nevertheless the survey across the whole island has confirmed the view that the earliest occupation by farming immigrants occurred in 4100–4000 cal BC in south-east England from Southampton Water to Lowestoft and that the expansion of farming throughout Britain and Ireland originates in that area. We have seen that this chronology matches the likely availability of the appropriate cultural stimuli on the near French/Belgian mainland.

Sheridan (2012), in a critique of this mono-focal approach to farming origins, draws attention to her long-pursued advocacy of the appearance of farming indicators in Ireland, possibly from sources in Brittany and Normandy, at a very early date, notably at the Mesolithic site at Ferriter's Cove, Co. Kerry in south-west Ireland (Woodman 1999). She also recognised, as we have seen, the strong case that exists for the early extension of a range of architectural ideas and other cultural traits, including ceramics, to Ireland at dates around 4000 cal BC or earlier. This is early in terms of the initial arrival identified by the *Gathering Time* project but, as we have seen, well within the availability of such material in north-west France.

At what chronological point this began to occur remains a problem that can only be resolved by attention to the chronology of those traits that appear to have been inherited by the emigrant groups. In Britain it appears that people were fully familiar with the engineering associated with rock quarrying. Mark Edmonds (2012) remarks, with reference to British axe quarries in the west, that around 4000 cal BC these stone sources saw the emergence of the distinctive practices that are associated with the procurement of stone axe blades. They exhibit changes that he associates with the development of processes of alteration and manufacture of Alpine axes in the Morbihan area of Brittany. In Britain these axes develop a similar ability to be 'reproductive of identity' that they have attained in Brittany. In Brittany, that capacity was fully developed by 4360–3890 cal BC, a date-bracket which must be regarded as the *terminus post quem* for the quarries at Plussulien, Côtes du Nord.

Sheridan (2003) has already shown that excavation at Les Fouaillages in Guernsey (Kinnes 1982) and La Commune-Sêche in Normandy (Kirk 2000) exhibit idiosyncratic parallels with burial monuments in southern and western Britain. The monuments appear to be associated with users of Cerny and Villeneuve St Germain pottery and their radiocarbon dates at 4800–4100 cal BC are consistent with that association. She also has drawn ‘the Achnacreebeag parallel’. This is one of a number of simple passage graves and closed graves in low cairns in the north-west Irish/north Irish Sea/Western Isles area that match early Breton types. At Achnacreebeag, Argyll, itself it was associated with pottery of close resemblance to Breton vessels of le Castellic type found in passage graves in the Carnac vicinity dated in the range 4300–3900 cal BC.

If there were refugees to Britain and Ireland in the face of the domination of a ‘theocracy’ in Southern Brittany between 4500–4300 cal BC it would appear that their cultural *milieu* included a number of features that emerged in Britain in succeeding generations. Axe factories were created at salient, and prominent, locations around the Irish Sea, most of which appear to be functioning by the early decades of 4th millennium. These axe factories had ‘down the line’ patterns of distribution (Group IV, IVa, VIII, IX (in Ireland) XV, XVI, XVII and XXVII). Axe factories with more complex patterns of distribution suggest target areas of distribution at some distance from the source and have less evidence for a diminishing ‘trail’ of objects sourced to that distant location (Groups I, III, IIIa, VI, VII, IX and XIX). It is likely that it will prove impossible to date the earliest working at any quarry site and we rely upon associative dating at the point of discard, loss, or final deposit of the implement. The lack of such likely associative location prior to 3800 cal BC makes even this approach difficult although a Group IX axe was found at the early fourth millennium causewayed enclosure at Magheraboy, Co. Sligo.

The one type of axe that is rare in Ireland and in the Irish Sea zone as a whole is the jadeite axe, both large and diminutive. This is perhaps an indication of the absence of Breton influence. Sheridan and Pailler (2012) assess, on stylistic grounds, that the arrival in Britain of these objects happened between 4100 and 4000 BC. The deposition of these objects is of known absolute date in one instance – the now famous Sweet Track find with its dendrochronological date of 3806 BC. At Cairnholy Isle in SW Scotland, close to the Irish Sea, its Clyde tomb association might suggest a similar date. Yet beyond the Irish Sea to the north in Scotland there is a comparatively large number of large jadeite axes – almost as many per area as in Wessex – in an area that might be thought to be less ‘taphonomically’ likely as there have been fewer excavations, less ploughing and less disturbance generally.

If Sheridan is right that the initial impetus of a Breton exodus to the Irish Sea area was one undertaken as an act of rejection on one or both sides, this could account for this very marked void in the distribution of these prestigious gifts that were, perhaps, in the furtherance of good relations with distant groups of the powerful. If so, the departure must have been, as we have seen, unpressured enough to ensure the time and resources that, as we have seen, such a voyage would require.

Discussion

There are many problems in the extension of archaeological comparison from one area to another, whether, as in this instance, from one side of the Channel to another or from the south and east to the north and west of the British and Irish Islands. This writer was interested to read in Gregor Marchand’s paper (2007) that ‘The present-day image of a Brittany steeped in folklore and economically retarded has probably played a crucial part in giving rise to the idea of a Mesolithic people unreceptive to the joys of agriculture’. It is a regrettable fact that similar prejudices exist between the south and east and the north and west in Britain. There is a vision of a Highland Zone (that implicitly and explicitly

included Ireland), monumentally inscribed by Sir Cyril Fox (1932) – to which this writer has responded (Mercer 1991) – in which the Highland Zone became the ‘refuge’ of peoples who were ‘refugees’ in the face of confrontation with incomers, always from the near continent or from across the North Sea. The Irish Sea was, and has been historically, the ‘back door’ into Britain. People in Ireland, Scotland and Wales as well as England have for centuries proceeded to the continent via Channel ports. The landings of the Romans are commemorated at Richborough, of Hengist and Horsa at Pegwell Bay, Kent, and of William of Normandy at Battle in Sussex. The whole cultural history and experience of Britain until the age of the jet aeroplane has been applied to that geographical focus.

Furthermore, the environment and nature of Britain and Ireland has changed radically, as the fragile soils in the north and west have deteriorated in the face of anthropogenic abuse and climatic change. Areas that are unattractive to a modern farming eye were, by virtue of the lightness of their soil and proximity to the sea, of prime attraction to early farming incomers.

To add to this there is an ‘archaeological cultural’ difference as well, imposed by circumstance, training, and the local economic and geological background. The transition from the Lowland to the Highland Zone in Britain involves a movement from soft to harder rocks, from drier to wetter climate and from soils that are inclined to be calcareous and alkaline to those that tend to be acid and base deficient. As a consequence, grazings of one kind or another dominate the agricultural land use of the north, the west and the south west. In the Highland Zone earthworks survive well on the whole, but other structures do not. Stone structures are often dilapidated to furnish material for their successors. Timber structures, of course, simply rot as elsewhere; however the chances of their discovery, or that of other levelled structures, are much reduced by the relatively few programmes of aerial reconnaissance and photography that apply in northern and western regions. This is partly by virtue of difficult conditions for flying and partly by the relatively poor performance of grazings in revealing information. The same environmental factors have constrained the amount of infra-structural development that Governments have felt justified or compelled to build. It is no accident that one of the most significant early Neolithic discoveries in Ireland, at Magheraboy, was made only because of the construction of the realigned N4 road (Danaher 2004). There are some important exceptions to these generalised observations: in South Leinster, and Meath in north-east Ireland, in the valleys of central and eastern Wales and in Scotland where heroic attempts have been made to extend aerial photography to the north and west. Nevertheless the contrast between highland and lowland areas in terms of understanding and the catalogue of known sites is still very considerable.

All of these factors – and others – have led to different emphases being laid upon varying monument types. Varying degrees of attention have been paid to different structures. There have been widely varying application of techniques such as radiocarbon dating. Dug cavities where post-occupation deposits can accumulate in stratified sequence are rare in hard rock areas, and stone-built cavity structures will not allow the perfect integrity of a sample’s context. In some areas the emphasis upon artefact studies is diminished by their scarcity, while in others funerary richness or complexity has proved all-consuming of effort.

Such variation occurs in every context internationally and it does make it very difficult to superimpose a standard template for the evaluation of data. There may be the need to exercise caution before accepting the primacy of south-east England in the transfer of farming to the islands of Britain and Ireland. Brittany may also have had a very early input to farming in Britain and Ireland. Indeed, if this is not the case, there is a need to explain the early dates of the passage tombs in Ireland in the Carrowmore cemetery, Co. Sligo and of the settlement at Ballynagilly, Co. Tyrone (rejected on the grounds that they were too early) and also the many dates from Magheraboy which exhibit an impressive uniformity between 4000 and 3800 BC.

Whatever the case, by the time that causewayed enclosures had been established in Britain and in use for 2–300 years there was a tradition of tomb architecture in Ireland and elsewhere around the Irish Sea that is monumental, idiosyncratic and betrays a range of explicit references to Breton funerary tradition. Is it not reasonable to suppose that the arrival of a relatively few farming fugitives might have required 400–500 years to establish themselves before beginning the great cemeteries of the north of the island?

The question remains open and requires more data to generate a conclusion. The available information tells us however that the transfer of farming to Britain was an arduous, hazardous exercise that originated among restless and changing societies from Brittany to south of the Rhine delta. The process was of some duration as some continental traditions, such as causewayed enclosure building, only commenced here in about 3800 BC, 200 years after the first arrivals observed with the Irish passage tombs. The differential social and economic complexity of the Breton *urheimat* is readily apparent in the Irish development and also possibly in the tension between south-west English farmers and their Wessex neighbours that is suggested by archaeologically detected changes at Hambledon Hill (Mercer and Healy, 2008). Those tensions and their lineal successors were eventually, by 3000 BC, to refocus the development of British Prehistory into a new insular identity.

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Integration of cereal cultivation and animal husbandry in the British Neolithic: the evidence of charred plant remains from timber buildings at Lismore Fields

Glynis Jones and Amy Bogaard

Introduction

The importance of cereal cultivation in the British Neolithic and its role in relation to the collection of wild plant foods and animal husbandry have long been the subject of archaeological debate. Some, like Tony himself (e.g. Legge 1989), have argued that cereals made a significant contribution to the Neolithic diet (e.g. Jones 2000; Monk 2000; Rowley-Conwy 2000; Jones and Rowley-Conwy 2007) and others that their contribution was limited (e.g. Entwistle and Grant 1989; Whittle 2003) and their role largely symbolic or ceremonial (e.g. Thomas 1993; Richmond 1999). In this context, the Lismore Fields timber buildings and the timber hall at Balbridie (Fairweather and Ralston 1993), with their rich charred plant assemblages, have been cited as evidence for the role of cereal cultivation in the British Neolithic (e.g. Thomas 1996; 1999; 2003; Cooney 1997; Richmond 1999; Dineley and Dineley 2000; Jones 2000; Monk 2000; Rowley-Conwy 2000; Jones and Rowley-Conwy 2007; Bishop *et al.* 2009), but with no general agreement on the interpretation of this evidence. The present contribution addresses this long-running debate in the light of the archaeobotanical remains from Lismore Fields.

The charred plant remains from Buildings I and II at Lismore Fields

The post-hole ground-plans of at least two Early Neolithic buildings were uncovered during excavations at Lismore Fields, Buxton, by D. Garton in 1985–1987. ‘Building I’ almost certainly comprises two separate buildings, each similar in size to Building II, but the relationship between these two structures is unclear, and it is uncertain whether or not they were contemporary (Garton 1991; in prep.). About half of the features (post-holes, pits and slots) associated with Building I and nearly all of the features associated with Building II were processed for charred plant remains. In the case of post-holes, the post-packing, post-pipe and upper fill were sampled and processed separately, where they could be distinguished (for a detailed account of sampling and recovery methods, and tables of botanical identifications, see Jones unpublished).

Buildings IE and IW

Charred cereal remains were recovered from all but two of the features sampled in 'Building I' and, in some fills, these were at relatively high densities (up to c. 350 cereal items per litre of deposit). The greatest concentrations of cereal remains were in the upper fills or post-pipes, supporting the view that the buildings were destroyed or cleared by fire (Garton in prep.), with charred plant remains falling into the post-pipes when the posts were removed, and collecting in the depressions at the top of the post-holes, but only rarely filtering into the post-packings. It is likely, therefore, that most of the charred remains date to the time of the buildings' demise.

Emmer wheat (*Triticum dicoccum*) was by far the most commonly occurring cereal (represented by both grain and chaff), though small numbers of grains more characteristic of free threshing wheat – bread wheat (*T. aestivum*) or rivet wheat (*T. turgidum*) – were found in a few samples. It is likely that the few grains resembling free threshing wheat were nothing more than contaminants of the emmer crop. Glume wheat chaff is usually represented on archaeological sites by the robust bases of glumes (with or without attached rachis internodes), whereas free threshing wheat chaff is usually represented only by fragments of rachis (the flimsy glumes having burnt away). No free threshing rachis remains were found to confirm the presence of free threshing wheat, though these tend to be removed with the straw at an early stage of processing, often away from settlement, while the glume bases of emmer are often removed at a later stage, usually in a domestic context (Hillman 1981; 1984; Jones 1984).

There was considerable variation in the proportions of grain and glume bases in samples from different features but remarkable consistency in these proportions in different fills (post-packing, post-pipe and upper fill) within the same post-hole. The relative proportions of wheat grain and chaff are plotted, for those features with more than 50 cereal items, as pie charts on a plan of the buildings (Fig. 25.1). Several of these relatively rich samples are from post-holes along the boundary between the eastern and western buildings (Buildings IE and IW). Grain predominated in two of these post-holes, on the eastern side of the boundary between the two buildings, and also in four post-holes and one pit in Building IE. Chaff (glume bases) predominated in two post-holes, on the western side of the boundary, and in two post-holes in Building IW. One post-hole, marking the east–west boundary on the south side of the buildings, contained substantial quantities of glume bases as well as grains.

In addition to wheat, small quantities (<10 g) of hazelnut shell (*Corylus avellana*) were found in most features and a substantial quantity in a pit in Building IE. Occasional seeds of crab apple (*Malus sylvestris*) were found in a few features, and a large quantity of flax seeds (*Linum usitatissimum*) in one posthole. Only one grain of barley (*Hordeum* sp.) was found, in the upper fill of a post-hole.

Building II

Charred plant material was recovered from all but two of the features sampled in Building II, but in much smaller quantities than in Building I. The relative paucity of charred plant material may be due to the loss of upper fills in many of the post-holes (Garton in prep.), or it may reflect a genuine absence. Cereals were particularly rare in Building II compared with Building I, wheat grains occurring in only two post-holes, and glume bases in low numbers (<10) in about a third of the post-holes. Flax seeds, hazelnut shell and crab apple seeds were found at frequencies similar to those in Building I, and included one whole crab apple.

The interpretation of the charred plant remains

The samples of relatively pure grain in Building IE apparently represent remnants from the storage of fully processed emmer, and in these respects resemble the grain found in the Balbridie timber hall, though the Lismore grain was found in smaller quantities and comprises predominantly one species whereas, at Balbridie, barley grain made up a significant proportion (c. 18%) of the total grain. Because the glumes that enclose the threshed grain are somewhat less likely to survive burning than the grains (Boardman and Jones 1990), it is also possible that the emmer in Building IE was originally stored as whole spikelets, the glumes having largely burnt away. The samples in which glume bases predominate, in Building IW, clearly represent by-products from the dehusking of emmer, as it is unlikely that glume bases would survive charring conditions that destroyed grain (Boardman and Jones 1990). Chaff remains are relatively uncommon at British Neolithic sites (Moffett *et al.* 1989; Jones and Rowley-Conwy 2007; Stevens 2007; Bishop *et al.* 2009) so these chaff-rich deposits provide the best evidence to date for emmer processing by-products in the British Neolithic. Processing by-products have also been found at other sites (Jones and Rowley-Conwy 2007), however, a notable example being the barley rachis remains found at Late Neolithic Scord of Brouster in Scotland (Milles 1986).

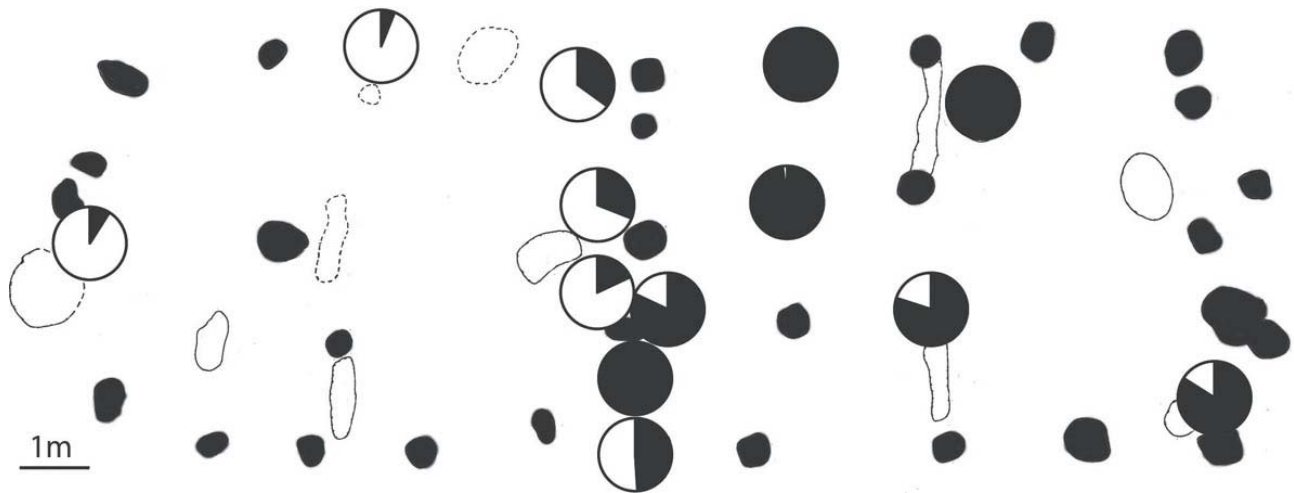


Fig. 25.1. Plan of Buildings IE and IW with pie charts representing the proportions of grains and glume bases in archaeobotanical samples with 50 or more cereal items. filled features = post-holes; empty features = pits and slots. Pie-charts: black = grains; white = glume bases. Base-plan of post-holes, pits and slots redrawn following Garton (1991, fig. 1.2).

The different crop processing (by-)products represented in Buildings IE and IW may reflect a difference in the function of these two structures, with storage of grain in Building IE, and dehusking activity or chaff storage in Building IW. A different function for the two buildings is also suggested by phosphate analyses: the highest phosphate values are mostly from features in Building IW while those in Building IE tend to be lower (Buck *et al.* unpublished). It is tempting to suggest that the association of chaff-rich samples with high phosphate values, and grain-rich samples with lower phosphate values, indicates that animals were kept in Building IW, at least some of the time, whereas Building IE was for human use, regardless of whether or not the two structures were contemporary. Some support for this comes from a few fragments of probable animal dung found in one of the chaff-rich post-holes on the western side of the boundary between the two buildings.

Stable isotope analysis

Emmer wheat grains from five grain-rich features in Building I were submitted for carbon and nitrogen stable isotope analysis (four samples from Building IE and one from the posthole on the boundary between the buildings with approximately equal quantities of grain and glume bases), as part of a broader isotopic study of crops from Neolithic sites across Europe (Bogaard *et al.* 2013). All five samples gave very similar results (Table 25.1). These are plotted (Fig. 25.2) in comparison with carbon and nitrogen isotope ‘thresholds’ for levels of watering and manuring respectively, derived from modern experimental and farm studies of cereals grown under known conditions of watering and manuring (Fraser *et. al.* 2011; Wallace *et al.* 2013). For the inference of crop water status, $\Delta^{13}\text{C}$ (which takes into account changes in the isotopic ratio, $\delta^{13}\text{C}$, of atmospheric CO_2 through time) is plotted; for the inference of manuring rates, the isotopic ratio $\delta^{15}\text{N}$ has been adjusted for the effect of charring by subtracting 0.31‰ (following Nitsch *et al.* 2015) before plotting in relation to modern isotopic thresholds.

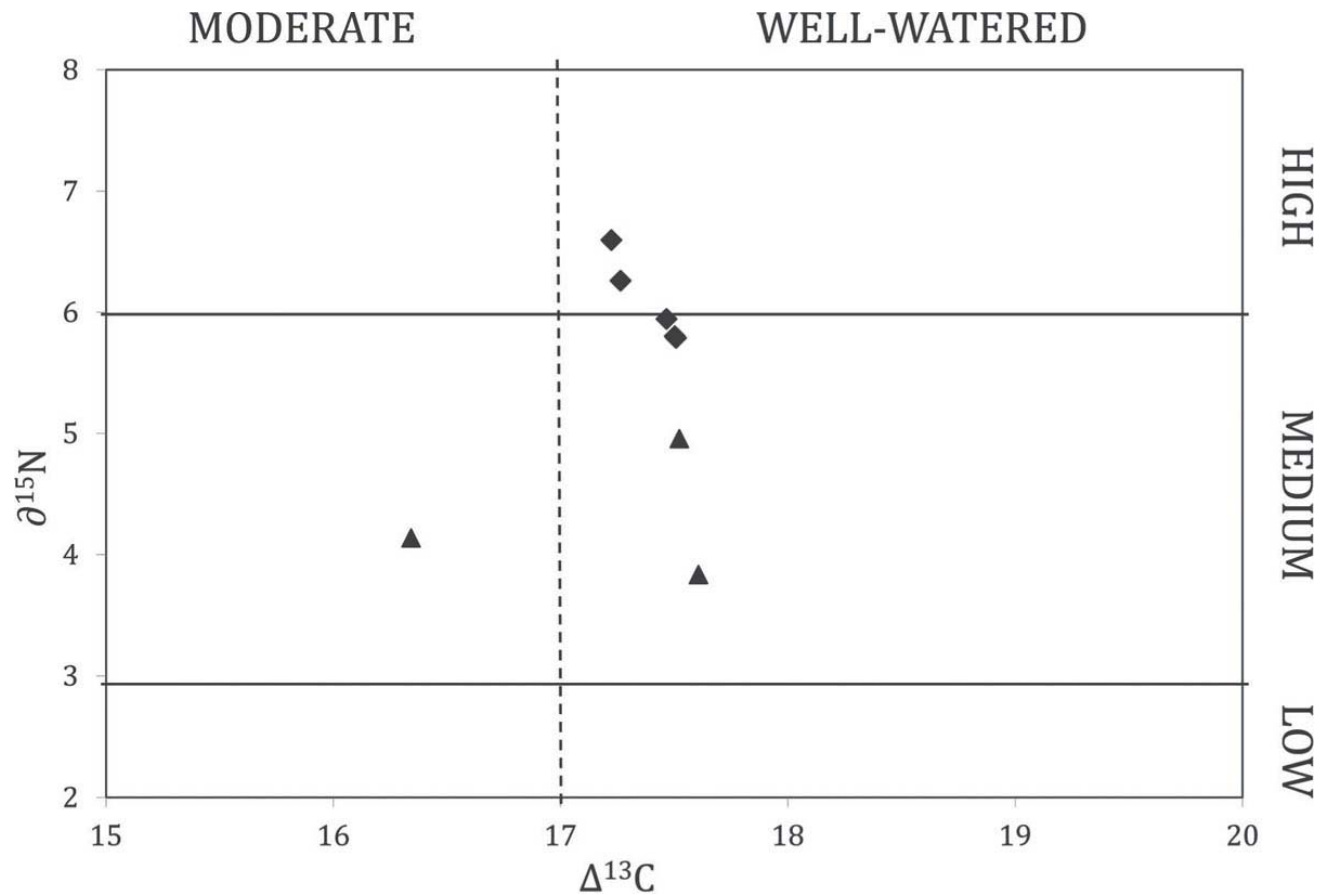


Fig. 25.2. Plot of $\Delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for emmer grain. Dashed vertical line represents the threshold for moderate and well-watered wheat (Wallace *et al.* 2013) and solid vertical lines represent the thresholds for low, medium and high manuring rates (Fraser *et al.* 2011), inferred from modern experiments and field studies. $\delta^{15}\text{N}$ values adjusted for charring by subtracting 0.31‰ (Nitsch *et al.* 2015). Diamonds = Lismore Fields samples; triangles = Hambledon Hill samples.

Table 25.1. Stable isotope determinations

<i>Sample</i>	$\delta^{13}\text{C}$	$\Delta^{13}\text{C}$	$\delta^{15}\text{N}$
BLF84	−23.47	17.51	6.10
BLF85	−23.46	17.50	6.11
BLF86	−23.19	17.22	6.90
BLF87	−23.43	17.47	6.25
BLF88	−23.23	17.26	6.57

The carbon isotopic results indicate that the emmer was reasonably well-watered, which is to be expected for cereals grown in a temperate climate. The nitrogen isotopic values are consistent with medium to high levels of manuring, similar to those obtained for wheat samples from two Neolithic sites in Greece and Bulgaria (Koufovouno and Slatina), for which significant rates of manure application have been inferred, and somewhat higher than three emmer wheat samples from the Stepleton Neolithic causewayed enclosure at Hambledon Hill, Dorset (Fig. 25.2; Jones and Legge 2008; Bogaard *et al.* 2013). This result is consistent with a degree of integration between crop cultivation and animal husbandry at Lismore Fields.

Discussion

The presence of relatively large quantities of emmer wheat in Building I should occasion no surprise as the most likely circumstance in which cereals would be preserved in quantity is when a building containing cereals is burnt down, or cleared by fire after it has gone out of use, preserving the charred remnants of activities, including storage, carried out within the building (Jones 2000; Jones and Rowley-Conwy 2007). Whether cleaned grain or processing by-products are found in such burnt buildings will depend on the function of the building, and Buildings IE and IW seem to have served different purposes, both involving the (by-)products of cereal processing. Relatively few cereal remains were found in Building II, which may not have been burnt or may have been used for a different purpose. There is nothing to suggest that the storage of emmer wheat grain in Building IE, whether as whole spikelets or free grain, was in itself unusual; storage is a normal aspect of the use of a staple, but seasonal, resource.

The emmer processing by-products in Building IW are interesting, first because the absence of cereal processing has been cited as evidence that Neolithic timber buildings in Britain were not associated with domestic activities, and may have had a primarily symbolic or ceremonial significance, housing a special type of food – cereal grain (e.g. Thomas 1996; 1999; Richmond 1999). The presence at Lismore Fields of a burnt building in which cereal processing took place, or where the by-products of this processing were kept, detracts from the argument for a special status of cereal grain. On the basis of the evidence presented here, it is possible to suggest a rather different interpretation. If indeed the co-occurrence of chaff-rich deposits and high phosphate levels (along with a few fragments of probable animal dung) indicates that animals were stalled in Building IW, and fed on cereal processing by-products, this may suggest the overwintering of livestock indoors. This in turn would have provided

the opportunity for the accumulation of animal dung that could then be spread on cereal cultivation plots, which would account for the ‘manuring’ signature observed in the nitrogen isotope values for the grain stored in Building IE.

It is uncertain whether Buildings IE and IW were in use at the same time (Garton 1991; in prep.) but, whether or not they were exactly contemporary, the activities represented in the two buildings may represent different aspects of an agricultural cycle operating during this period of the site’s occupation. The close integration of crop cultivation and livestock management implied by this interpretation of the evidence would constitute a highly sustainable mixed farming system, similar to that argued for other parts of Europe in the Neolithic and Bronze Age (e.g. Halstead 1981; 1989; 1996; Rowley-Conwy 1981; Bogaard 2004; 2005; Bogaard *et al.* 2013). For Neolithic crop cultivation in Britain, it has been argued that ‘it is questionable whether stands of crops would have been maintained in the same location for long, rather than being opportunistically seeded in available clearings’, especially given the lack of evidence for legume crops which could have been grown in rotation with cereals (Thomas 1999; 2003). The integration of livestock husbandry with cereal cultivation suggested here for Lismore Fields provides an alternative means of maintaining soil fertility in fixed cultivation plots, and implies a type of livestock management rather different to the mobile pastoralism, largely divorced from limited or sporadic cultivation of cereals, envisaged by some for the British Neolithic (e.g. Thomas 1999; 2007; Stevens and Fuller 2012). As such, the Lismore Fields cereal remains may provide the first concrete evidence for integrated mixed farming in the British Neolithic.

Of course, the evidence presented here applies only to Lismore Fields, and should not be extrapolated to other parts of Britain without supporting evidence in these areas, and it is beyond the scope of this paper to consider whether the relative rarity of Neolithic timber buildings in Britain (compared with Ireland and mainland Europe) is evidence for their absence or merely indicates that their survival is unusual (see Monk 2000 and Rowley-Conwy 2000 for discussion of these issues). Suffice it to say that rarity in itself should not be seen as a reason for discounting the evidence of archaeobotanical remains, as it would be usual for food (and fodder) to be eaten rather than burnt, and it is unsurprising that charred plant remains are more often found in burnt buildings than at unburnt sites (cf. Thomas 2007). If the use of cereal by-products as fodder in the Neolithic were widespread, however, it would go some way towards explaining the rarity of chaff on most Neolithic sites. Campbell (2000) has suggested that the use of cereal by-products as fodder may explain the relative paucity of chaff at some Iron Age sites in the Danebury area and Upper Thames Valley, as chaff destined for fodder would be less likely to find its way onto household fires. Cereal chaff, like grain, would then be found in quantity only when a building in which it was stored or used was exposed to fire. This is not inconsistent with Stevens’ suggestion (2007) that Neolithic cereals, including emmer wheat, were dehusked in bulk soon after harvest, and stored fully processed, as this would generate significant quantities of chaff that, along with straw, could provide a useful source of fodder.

The type of integrated mixed farming suggested for Lismore Fields does not imply extensive land clearance or field systems (cf. Richmond 1999; Thomas 2003) but rather, if anything, is more consistent with small-scale cultivation and animal husbandry, where cultivated plots are located near to settlements, facilitating the collection and application of manure (Jones 2005). This would be consistent with the pollen evidence for limited woodland clearance in the Early Neolithic (Richmond 1999). Stall-feeding of livestock also suggests the keeping of modest numbers of animals, which would arguably be inconsistent with mobile pastoralism (e.g. Halstead 1996). A further implication of a potentially widespread mixed farming economy relates to its inherent sustainability. On the basis of radiocarbon dates for cereal grains, it has recently been suggested (Stevens and Fuller 2012) that, after an initial flourishing of cereal cultivation following its introduction to Britain in the Early Neolithic (possibly

accompanied by an increase in population), cereals were all but abandoned around 3650–3600 cal BC (with a corresponding decline in population) to re-emerge later in the Middle Bronze Age. The sudden decline in agricultural activity in the Late Neolithic is attributed to climatic deterioration. While it is reasonable to suppose that, faced with adversity, early farmers might have chosen to diversify and make more use of wild resources, it is unclear why they would, as suggested, have abandoned one element of a relatively stable mixed farming strategy to opt for a more specialised and riskier reliance on mobile pastoralism (Stevens and Fuller 2012). It is possible that the lack of cereal radiocarbon dates in the Late Neolithic and early Bronze Age owes more to the selection of material for dating than to any actual rise or fall in the cultivation of cereals.

Conclusions

The unusual preservation conditions provided by burnt timber structures at Lismore Fields have preserved evidence not only of grain storage but also of cereal processing. This in turn has allowed us to address research questions that can rarely be attempted for the British Neolithic due to a lack of burnt buildings at other sites. On the basis of the combined evidence of the botanical composition of the cereal assemblage, stable isotope analysis of the grain, and soil phosphate analyses, it has been suggested that animals may have been stalled overwinter at Lismore Fields, fed on cereal processing by-products, and that their dung was used to manure cultivated cereal plots. Such a mixed farming regime represents a radical alternative to the widely accepted view that Early Neolithic communities merely incorporated cereals into their seasonal activities of wild plant collection and mobile pastoralism, though we concur with most other authors that different strategies may have been employed in different parts of the country and that wild resources may have acted as a buffer against crop failure.

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Taphonomy and cultural selection: Tony Legge and the Neolithic pits beside the Dorset Cursus

Richard Bradley

Introduction: the Late Neolithic pits beside the Dorset Cursus

The year 1991 was a good one for Neolithic pits. It was when Julian Thomas published his book *Rethinking the Neolithic*, and it also saw the publication of Martin Green's excavations at Down Farm in Cranborne Chase (Barrett *et al.* 1991, 75–84).

Thomas identified a number of problems with existing studies of Neolithic pits and their contents (1991, chap. 4). He suggested that these features were the wrong size and shape to have been used for storing cereals. A number of them contained exceptional assemblages of artefacts, and there were examples whose contents seem to have been placed in the ground with some formality. His analysis was necessarily based on published sources, few of which referred to any of these problems. Thomas asked several important questions. Were the pits dug and refilled on special occasions, and how were they related to the ancient pattern of settlement? Were they associated with domestic sites, or did they occupy more isolated positions in the landscape?

By the time that Martin Green's fieldwork came into print it was already apparent that Neolithic pits would be difficult to interpret. It was especially hard to understand those associated with Grooved Ware as they contained an unusually wide range of artefacts and faunal remains. The excavated pits at Down Farm included elaborately decorated pottery, axes of non-local stone, small groups of antlers, a distinctive banded pebble, a cow's skull and even the ulna of a brown bear. Moreover, they were located close to an enormous monument which still retained its significance a thousand years after it had been built. This was the Dorset Cursus, the largest earthwork of its kind in Britain. The pits themselves were dug during the later third millennium BC (Barrett *et al.* 1991, chaps 2 and 3).

They were found in two groups, one of which was fully excavated, whilst another extended beyond the area examined by Martin Green. There was a single outlier. They were discovered entirely by chance during work on a Middle Bronze Age enclosure which occupied the same site in Firtree Field. There were also clusters of stake-holes which were assigned to the Neolithic period as they did not conform to the plan of the later settlement. It seemed possible that some of them defined curvilinear structures about 3 m in diameter. Since 1991, similar pits have been found on another site close to the Cursus on Wyke Down (French *et al.* 2007, 83–94). In this case they were associated with a pair of circular buildings and two henge monuments. The results of those excavations are not

considered in detail here.

At first sight the pits published in 1991 conformed to the pattern identified by Julian Thomas in the same year. They were generally small and circular or oval in plan. They had not remained open for long and had been refilled with a restricted number of deposits, a few of which contained large quantities of artefacts and animal bones. At times their contents seemed to have been carefully placed in the ground. This was especially true of the group of features facing the Cursus. One of them contained two pig's canines together with a stone axe and a flint scraper. On the bottom of another was an antler covered by a cow's skull; there were more antlers at a higher level in the filling. In a similar feature a pig's mandible was found together with another stone axe, whilst a further example included a deposit of six antlers. Such patterns were not confined to the animal remains. There was a Grooved Ware pit containing a large slab of pottery which had been placed in the ground with its decorated surface uppermost. The worked flints from the excavation illustrate another unusual feature. They came from two different sources: fresh pieces originating in the local chalk, and more worn artefacts made of river gravel. Post-excavation analysis found that chalk flint was usually associated with axes, arrowheads, serrated flakes and decorated pottery. They were also found in pits with pigs' jaws, cattle skulls and antlers. By contrast, the other group was more often accompanied by plain sherds and smaller pieces of bone.

To that extent the results of Martin Green's excavation conformed to the wider pattern identified by Julian Thomas, but here there was a problem that had not been addressed before. What was the source of this material, and could the excavated artefacts have been associated with some kind of settlement? The presence of stake-holes suggested that this might have been an occupation site, and subsequent excavation not far away on Wyke Down found similar deposits associated with two buildings that were interpreted as houses (French *et al.* 83–88). They have close parallels in other settlements associated with Grooved Ware in Britain and Ireland (Noble *et al.* 2012, 149–167). In a way it was unfortunate that the Late Neolithic pits published in 1991 were on the same site as a Middle Bronze Age enclosure as it meant that the lithic artefacts recovered from the topsoil dated from two different periods. It made it impossible to use the distribution of surface finds to map the extent of Neolithic activity. In any case some of these artefacts may have come from the upper levels of pits that had been truncated by the plough.

Tony Legge and the Grooved Ware pits at Down Farm

By good fortune Tony Legge offered to analyse the faunal remains from Firtree Field, and his report helps to answer some of the questions raised in the introduction to this paper (Legge 1991). It provides an important source of reference for studies of Neolithic subsistence, but his contribution to the investigation of pit deposits has been overlooked. In many ways that work was ahead of its time, for he considered issues that were not discussed in any depth for another ten years or more. This epitomises a wider problem in modern archaeology where studies of animal bones are too often treated as a self-contained sub-discipline. Their wider implications rarely influence people working in other parts of the subject. Tony was exceptional in this respect, for he was interested in both the details and the wider picture. That is why it is important to draw attention to what he said nearly a quarter of a century ago.

As the title of this article suggests, Tony considered the relationship between the condition of the bones at Down Farm and the processes by which the pits were filled. One point was obvious from the outset. These features contained very different quantities of artefacts and faunal remains, and not all of them were dominated by the same species. Thus one pit included a large collection of well preserved animal bones, which were mainly those of cattle. Among them was a skull that had been

buried after it had lost its flesh. In this case wild animals were represented in unusual numbers. That contrasted with the pattern elsewhere on the site where pig was the commonest species. Interestingly, there were similar contrasts at the nearby site on Wyke Down where two small henges were excavated. Although they were not associated with many bones, in one case cattle were more common than pigs, but in the neighbouring monument (which shared the same form and date) the proportions of those species were reversed. Near to the enclosures there were more than twenty pits like the examples published in 1991. Although few fragments survived, again there was most evidence of pig bones (French *et al.* 2007, 319–320).

As Tony observed in his report, similar contrasts extended to the finds of antler from the pits in Firtree Field. Some had been used as tools, but this was not true of the rest, and there was no obvious relationship between the number that were found and the quantity of animal remains in the same features. Thus the largest collection of antlers was associated with a few bones and teeth. Larger items such as picks and rakes or the complete cattle skull might have been chosen for burial and the same is true of the more elaborate stone objects, but did that apply to the other material found in the pits?

Among this collection was the ulna of a brown bear. It recalls a find from a Grooved Ware pit close to Woodhenge (Stone 1935, 66), but Tony's comment is revealing:

The state of this bone shows that it spent some time upon the ground surface where it was accessible to dogs. Although it is tempting to argue that a bear bone had a special significance in a Neolithic pit, there is no direct evidence for this. The condition of the bone ... suggests only that the assemblages in the pits were accumulated by bones being gathered from a ground surface. Perhaps the size of the fragment was of more note than the ... species from which it came.

(Legge 1991, 61)

A similar argument applied to most of the faunal remains in the Grooved Ware pits at Down Farm. Tony commented on the unusually low proportion of unidentifiable material in this collection. He studied its composition by drawing on the studies of bone survival carried out by Binford and Bertram (1977). He also compared the contents of the Neolithic pits with those of the Bronze Age enclosure on the same site, for in this case there was nothing to indicate any kind of structured deposition.

It was clear that the Neolithic animal bones were unexpectedly large and well preserved and that smaller pieces which could not be assigned to a particular species were remarkably rare. That was particularly surprising because it was clear that individual fragments had been gnawed by dogs before they were buried. What Tony had concluded about the ulna of a bear applied to the collection as a whole. 'The bones in the pits were mainly large fragments such as mandibles and articular ends of limb bones, and the whole assemblage was biased towards those bones having the highest density' (Legge 1991, 68–69).

Why had this happened? The evidence that particular bones had been attacked by scavengers showed that they had been accessible before they entered the pits. The most likely source was a midden, and it was here that some pieces underwent so much attrition that only small fragments survived. This had a further implication, for it suggested that certain bones had been chosen rather than others. Again Tony had an explanation:

It is argued that the bones in the pits simply represent a collection made from those available on the ground surface at a settlement, but showing a considerable degree of selection. It is probable that the

main criterion in the selection of bones was size. The association of cattle and pig skulls, deer antlers, decorated potsherds and other artefacts in apparently purposeful arrangements argues that the bones too were deliberately included (rather than being simple waste disposal).

(Legge 1991, 67–68)

The same observations would apply to the small collection of animal bones from the Grooved Ware pits at Wyke Down (French *et al.* 2007, 319–320). That comparison is important as they seem to have been associated with a pair of domestic buildings as well as two henge monuments. The features in Firtree Field may illustrate the same interplay between ritual and everyday activity (Bradley 2005). The presence of such a high proportion of pig bones on both sites suggests that feasting took place, but that is no reason to assume it was their only function. In any case, the condition of the faunal remains shows that, even if this interpretation is correct, the debris created by these events was left on the ground before part of it was buried.

This analysis went some way towards answering the questions raised by Julian Thomas in the same year. The pits at Down Farm may have been filled by material selected from a midden and were probably associated with an occupation site that included ephemeral wooden buildings, although this was impossible to prove. Those pits were by no means isolated and, like their counterparts on Wyke Down, they were also close to a monument, or monuments. Certain artefacts may have been deposited in a formal manner, but that need not have applied to the collection as a whole. Indeed, the report on the lithic artefacts from Firtree Field, suggested that they too contained midden material (Brown 1991). Certain deposits could have been more specialised than others. Some of the material may have been generated during feasts, but it does not follow that it applied to the entire collection. In the same way, work on Rudston Wold in Yorkshire – a location close to the site of another cursus – suggests that people who were using Grooved Ware may well have feasted on pork, but they also dug pits which provide no evidence of structured deposition (Harding 2006; Rowley-Conwy and Owen 2011). In this case a surface scatter of Neolithic artefacts was recorded in the ploughsoil.

Since 1991 Tony's analysis has been substantiated by the results of new research, but it seems extraordinary that it took so long for this to happen. By then his original paper was rarely cited and his ideas were largely overlooked. New work on the pottery from Neolithic pits in East Anglia suggests that sherds could have been broken, weathered or burnt before they were buried. The contents of neighbouring pits had undergone different amounts of attrition by the time that they were deposited (Garrow *et al.* 2005). Similar observations have been made in studies of the lithic artefacts from these features (Lamdin-Whymark 2008), and a small number of excavations have begun to explore the middens from which this material was collected – all too often they are machined away before any pits are found. There has been new research on the placing of such features in relation to one another (Anderson-Whymark 2012), and Jessica Smyth (2012) has investigated their associations with domestic buildings in Ireland.

By now it has become obvious that there was more variation in this evidence than anyone had expected, but it was Tony Legge's analysis of the animal bones buried beside the Dorset Cursus that should have set the agenda for the new research. It is a pity that this has rarely been acknowledged, and it is right to draw attention to his achievement now.

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Humans and animals in Mesolithic, Neolithic and Bronze Age Dorset

Mark Maltby

Introduction

One of Tony Legge's many lasting legacies is the contribution he made to the study of animals from Neolithic and Bronze Age sites in Dorset. He provided detailed analyses of the animal bones from six prehistoric sites on Cranborne Chase (Legge 1991) and more recently his comprehensive study of the bones from the causewayed enclosures and other Neolithic sites on Hambledon Hill has been published (Legge 2008). He used information from these studies to furnish several discussions on prehistoric animal husbandry and exploitation patterns (e.g. Legge 1981a; 1989). Given that I have also worked on some bone assemblages from the same periods and area, it seems an appropriate tribute to Tony, to review our current understanding of the zooarchaeology of the prehistoric period in Dorset. This paper will also draw upon some of the observations on animal exploitation in the region that were incorporated within the reviews of Serjeantson (2011) and Hambleton (2008).

The later Mesolithic (6000–4000 BC)

Although a number of inland and coastal sites dating to the later Mesolithic period are known in Dorset (e.g. Rankine 1962; Palmer 1999), little is known about animal exploitation. Marine shellfish were exploited on the Isle of Portland (Mannino and Thomas 2001) and bones of red deer, pig and cattle (presumably wild) were recovered from late nineteenth century excavations at Blashenwell, near Corfe Castle (Preece 1980). There are several Late Mesolithic sites in Cranborne Chase but the only significant faunal assemblage has been obtained from the Fir Tree Field shaft (FTF 92–94; Fig. 27.1). This included two partial skeletons of immature roe deer that possibly fell into the shaft plus a few other bones of roe deer, red deer, and wild boar, some of which do bear evidence of processing. Together with the presence of several microliths, this shows that wild mammals were being hunted in the area (Maltby 2007a). Unfortunately very few bones were obtained from the transitional Mesolithic/Early Neolithic layer in the shaft, which contained a few fragments of cattle and pig, small enough to be considered domestic, alongside antler and bones of red deer, roe deer and aurochs. However, the sample is too small and mixed to refute or support the impression gained elsewhere in southern England that there was a rapid shift from the exploitation of wild to domestic animals in the Early Neolithic (Serjeantson 2014).

The Early and Middle Neolithic (4000–3000 BC)

Tony Legge's (2008) work on the sites on Hambledon Hill will deservedly be regarded as the cornerstone of zooarchaeological studies for causewayed enclosures in Dorset. Although faunal assemblages have been examined from other enclosures in the county, including those from Maiden Castle (Armour-Chelu 1991), the assemblages from the Main and Stepleton Enclosures on Hambledon Hill are far larger, which enabled more detailed analysis. There are also smaller assemblages from a range of other early Neolithic features within the complex providing a total of over 7,800 identified elements. Readers should refer to the original report (Legge 2008) to appreciate the quality of his analysis fully, but the main conclusions can be summarised as follows:

- (a) cattle were the dominant species represented, throughout the Hambledon complex, contributing between 60–70% of the post-cranial element counts.
- (b) domestic pigs were the second most commonly identified species (20–30%).
- (c) sheep/goat (mainly sheep) formed between 15–20% of the post-cranial elements.
- (d) pig and sheep/goat mandibles were better represented than post-cranial elements because of better preservation but in terms of meat weight, cattle dominated.
- (e) there were only small percentages of wild species, mainly red deer and roe deer.
- (f) there was a high proportion of immature and young adult cattle represented.
- (g) the majority of the adult cattle represented were female.
- (h) most of the pigs were killed in their second year.
- (i) there were a number of associated bone groups from the complex including segments of cattle vertebrae, groups of red deer antlers, a largely complete dog and two partial goat skeletons.

Complementary to Legge's zooarchaeological research, lipid residue analysis has shown that both ruminant meat and dairy products were commonly consumed (Copley *et al.* 2008). Isotope analysis has shown that the diet of most of the people sampled was quite high in protein (Richards 2008).

The impression gained from the excavations is that the Hambledon enclosures were used as venues intermittently but regularly for major gatherings which included the consumption of large quantities of food, particularly meat.

Legge pointed out that the assemblage from the Hambledon complex may not represent a typical pattern of consumption. This is an issue that makes interpretation of British Neolithic faunal assemblages challenging. The largest assemblages, whether from causewayed enclosures such as Hambledon Hill and Windmill Hill, Wiltshire (Grigson 1999) or from later Neolithic henge enclosures such as Mount Pleasant, Dorset (Harcourt 1979) and Durrington Walls, Wiltshire (Harcourt 1971; Albarella and Serjeantson 2002), are from sites that were often used for large-scale gatherings. The curious assemblage dominated by domestic cattle head and foot bones and bones of roe deer from the early Neolithic pit at Coneybury, Wiltshire (Maltby 1990; Legge 2008, 555; Serjeantson 2014) may be another example, as could the pig-dominated assemblage from a pit at Rowden, Dorset, possibly redeposited from a midden, (Maltby 1991a; Harris 2009). Food consumption at these gatherings may have been very different from the normal dietary pattern.

Similarly, the deposition of complete or partial skeletons of animals is a feature of many Neolithic assemblages. Although their frequency in the Dorset causewayed enclosures themselves at Hambledon Hill and Maiden Castle (Armour-Chelu 1981) is less than at Windmill Hill (Grigson 1999), several associated groups, mainly of cattle, but also of roe deer, sheep, goat and dog were found in the

long barrow, cross dykes and outworks within the Hambledon complex (Legge 2008; Serjeantson 2011, 152–153). Interpretations of such groups depend on context, completeness, butchery and other taphonomic evidence. For example, the complete dog skeleton from Hambledon could have belonged to a pet that was afforded a burial in a special place, whereas the associated cattle vertebrae could be butchery waste or perhaps a symbolic sacrifice of food associated with feasting events. Serjeantson (2011, 30–31) has suggested that the partial goat skeleton from the outer cross-dyke at Hambledon may have belonged to an animal that acted as a guide to sheep flocks and was thus highly regarded and afforded a special burial.

Irrespective of whether the animal bones from Hambledon represent typical dietary and disposal patterns, the predominance of cattle is a common feature of assemblages from causewayed enclosures and other earlier Neolithic sites in southern England (Serjeantson 2011, 14–16; 2014). Legge's (1981a) influential and often cited paper on cattle husbandry, was largely derived from his initial analysis of the bones from Hambledon and the Middle Bronze Age assemblage from Grimes Graves, Norfolk (Legge 1981b). Most of his conclusions have stood the test of time. His metrical analysis of the limb bones from Hambledon, Windmill Hill and Durrington Walls (Legge 1981a, 176–177) showed a bias towards cows, which has been confirmed by subsequent analysis of further material from these sites (Grigson 1999; Legge 2008). The bias towards females and the presence of relatively large numbers of mandibles from calves led to the conclusion that dairy production formed a significant role in cattle husbandry in the Neolithic (Legge 1981a). Lipid analysis has since confirmed that ruminant dairy produce was deposited fairly frequently on pottery at Hambledon Hill and on other causewayed enclosure sites (Copley *et al.* 2005; 2008). The overall mortality profiles from Hambledon (Legge 2008, 541–544), however, do not show that there was intensive culling of calves there, with only c. 20% of the mandibles being from animals under 12 months old. Indeed there are high percentages (55–60%) of cattle killed between 18 and 36 months, suggesting that many cattle brought to Hambledon were not animals that had been exploited for secondary products for any length of time. There was a focus on meat consumption here. Legge (2008, 543–544) suggested that male calves and surplus young sub-adult and adult cows not required for breeding or milking were the ones usually selected to be brought to the enclosure for slaughter. There is also little evidence from here or other Neolithic sites in Dorset that cattle were commonly used as plough animals.

The majority of pigs at Hambledon were culled in their second year and few young piglets were represented (Legge 2008, 548–549). Provided they survive taphonomic decay, more mandibles of juveniles would be expected if pigs were being raised in or around the enclosures. Again, this would suggest a focus on the culling of second-year pigs, many possibly brought to the sites from elsewhere.

Serjeantson (2011) has rightly observed that the abundance of sheep in earlier Neolithic sites in southern England has probably been underestimated in earlier surveys. At Hambledon, sheep were relatively well represented in both enclosures and in most of the smaller assemblages from other features (Legge 2008; Serjeantson; 2011, 138). However, excluding the goat skeletons, they provided only 17% of the total counts of cattle (58%), pig (24%) and sheep/goat (Serjeantson 2014). They were less well represented than in the causewayed enclosure features at Maiden Castle (Armour-Chelu 1991), where sheep ranked second (27%) behind cattle (52%) with pig third (19%) in the NISP counts. The bank barrow at Maiden Castle produced similar species ratios (cattle 54%; sheep/goat 23%; pig 20%; red deer 3%).

The low percentage (3.6%) of bones of wild species in the Hambledon complex is typical of other earlier Neolithic sites and supports the argument that the Neolithic 'package' from the continent, including the introduction of domestic forms of cattle, sheep, goat and pig, spread rapidly in southern Britain in the early fourth millennium BC (Serjeantson 2014). At Hambledon, red and roe deer

contributed little to the meat diet and bones of wild boar and aurochs were also only occasionally identified (Legge 2008). Several of the aurochs bones came from the south long barrow (Legge 2008, 561). Jackson (1936) reported the presence of two aurochs skulls in the ditches at a long barrow at Thickthorn Down. Aurochs skulls were also recorded at Maiden Castle (Armour-Chelu 1991). The association of aurochs in large burial monuments and other communal structures such as the Dorset Cursus (see below) may reflect their importance in symbolic deposition. Domestic cattle skulls have also been quite commonly found in such contexts elsewhere in southern England (Serjeantson 2011). Another example from Dorset is the skull, probably from a domestic bull, found in the primary fill of a long barrow at Alington Avenue, near Dorchester (Maltby 2002).

Red deer counts at Hambledon and Maiden Castle, and at many other Neolithic sites, are supplemented by the presence of antlers, sometimes manufactured into picks (Legge 2008, 573–582; Serjeantson 2014; Worley and Serjeantson 2014). A single goose bone represents the only species of wild bird from sites in earlier Neolithic Dorset and Maiden Castle is the only site to have produced fish (but only two bones each of cyprinids and trout) (Serjeantson 2014). Isotopic signatures from Hambledon Hill show that marine foods were rarely, if ever, eaten by the people represented there (Richards 2008).

Most of the Middle Neolithic faunal evidence has been obtained from Cranborne Chase. Excavations of the Dorset Cursus at Down Farm provided only 30 identified elements (Legge 1991, 54–55). Twenty-one of these were cattle, including tooth rows of one or more skulls from the upper fills of one ditch section. Significantly, six bones of aurochs were also recorded, forming a much higher proportion of the bovine assemblage than anywhere in the Hambledon complex. Two bones of red deer and one of pig were also identified.

Dating from the latter half of the fourth millennium BC and thus broadly contemporary with the Cursus was the Monkton-up-Wimborne pit complex (MUW97; Fig. 27.1). At the centre of this complex was a wide pit, at the edge of which four inhumations, possibly sacrificial victims, were interred. Shortly after, a 4.5 m deep shaft was inserted through the pit's southern edge. The pit was ringed by 14 smaller pits (Green 2000, 79–84; 2007a). The lower fills of the shaft were interspersed with depositions of chalk and sandstone objects, arrowheads and a few disarticulated human bones. Near the base of the shaft was a partial carcass of a juvenile pig showing evidence of butchery and charring. Other small groups of associated bones of pig and cattle were also recovered along with a complete skull and a horncore of male cattle and a complete mandible and tibia of dogs. Associated with a few sherds of Peterborough Ware, these and other disarticulated animal bones, some with evidence of butchery, probably represent symbolic depositions sometimes associated with food consumption. A total of 46 bovine bones were recovered from these shaft fills, including an aurochs humerus. In addition to the 19 bones from the butchered piglet, 40 bones of pig (probably all domestic) were recovered. The 21 red deer antler fragments ranged in size from fairly complete picks to small, often eroded and burnt, fragments. However, significantly, no sheep/goat bones were identified (Maltby 2007b).

Sheep/goat was also absent in an assemblage of 94 identified fragments of larger mammals in layers associated with Peterborough Ware in the Fir Tree Field shaft. Cattle provided 51% of the identified material, followed by pig (36%). Five bone and three antler fragments belonged to red deer and two bones each of roe deer and aurochs were also recorded (Maltby 2007a).

Evidence for animal exploitation during the Middle Neolithic from elsewhere in Dorset is extremely limited. The primary fill of the late fourth millennium enclosure at Flagstones, near Dorchester, only produced two vertebrae and 14 fragments of antler of red deer and three bones of dog/fox. Slightly earlier pits from this site produced just 16 identified fragments, all of cattle (Bullock

and Allen 1997).

The later Neolithic to the Early Bronze Age (c. 3000–1500 BC)

Although there are several assemblages from Dorset dating to this period, none approach the size of the one from Hambledon. Much of the evidence again comes from the Cranborne Chase area around Down Farm (Fig. 27.1), where excavations have produced a number of assemblages with faunal assemblages that have been mainly analysed by Legge (1991) and this author (Maltby 2007a; 2007b; Maltby *et al.* 2007; Rothwell and Maltby 2007). Material from other areas of Dorset is sparse, although the Dorchester environs have produced several samples which will also be discussed.

Grooved Ware assemblages

It has long been recognised that British later Neolithic assemblages, particularly those associated with Grooved Ware, often contain large amount of pig bones (e.g. Grigson 1981), with samples from major monuments such as the Durrington Walls henge enclosure (Harcourt 1981; Albarella and Serjeantson 2002) and the West Kennet palisade enclosure (Edwards and Horne 1997) in Wiltshire being cited as prime examples. Many of these sites are considered to have been associated with feasting. Recent reviews have largely confirmed this trend (e.g. Serjeantson 2011), although Rowley-Conwy and Owen (2011) have shown that there are some regional variations with several assemblages from Yorkshire and the east Midlands containing more cattle than pig.

Indeed, Tony Legge's analysis of Wyke Down 1 henge on Cranborne Chase (WD1; Fig. 27.1) also showed that not all Grooved Ware assemblages are dominated by pig. Although restricted to 59 identified fragments obtained from the ring of pits that formed the enclosure, the assemblage was dominated by cattle (76%) with pig (15%), sheep/goat (5%) and red deer (3%) represented in small numbers (Legge 1991, 56–58). Similarly, the assemblage of 122 identified fragments from the adjacent Wyke Down 2 henge ditch (WD2; Fig. 27.1) was also dominated by cattle (67%), followed by pig (28%), sheep/goat (3%) and roe deer (3%) (Rothwell and Maltby 2007). In contrast, pig provided 60% of the 294 fragments identified to the larger mammals found in pits from the adjacent settlement area. Cattle contributed only 34% and sheep/goat just 5% of this sample. Red deer, roe deer, dog and fox elements were also present in small numbers. The Grooved Ware pits from Fir Tree Field (DF78; Fig. 27.1) produced 144 fragments, of which 48% were identified as cattle, followed by pig 42%. Sheep/goat elements (5%) were again poorly represented. However, the higher percentage of cattle bones overall on this site was the result of their predominance in one of the pits (11A). Pigs outnumbered cattle in the other pits (Legge 1991, 65; Rowley-Conwy and Owen 2011, 333). Legge's (1991) detailed analysis of fragmentation patterns and taphonomic data showed that larger bones were preferentially selected from surface middens for deposition in all the pits, particularly pit 11A, which included a complete cattle skull. This was also the only pit that produced bones (rather than antler) of red deer and roe deer, as well as the exceptional find of a bear's ulna that, like many of the other bones, had been gnawed by dogs before deposition.

A short distance away, two more Grooved Ware pits adjacent to the Fir Tree Field shaft produced a total of 43 identified fragments, of which 28 belonged to pig, 13 to cattle and two, including an antler tine, to red deer. Again, bones of sheep/goat were not identified. Many of the bones were charred and, as in several of the other pits discussed above, included bones placed on the base of the pits sometimes in close association with unusual artefacts, in this case flint axes and nodules (Maltby

2007a).

The assemblage from a Grooved Ware pit at Barford Farm, Pamphill, near Wimborne in east Dorset, produced an assemblage of 159 identified fragments again dominated by pig (71%). Cattle provided 28% of the bones. There were two elements of red deer but bones of sheep/goat are again conspicuous by their absence (Maltby 1989).

The best known of the Grooved Ware faunal assemblages from the Dorchester environs comes from the Mount Pleasant henge enclosure (Harcourt 1979). Species counts based on minimum numbers of 37 individuals produced 46% pig, followed by 22% cattle and 11% sheep/goat. Bones of wild species (aurochs, boar, fox, red deer) were recorded in small numbers along with dog and horse. One bone of a crane was also recovered. The date of the horse bone has not been confirmed by radiocarbon dating but, if authenticated, would represent one of the earliest finds of this species in southern England (Serjeantson 2011, 32–33). In contrast to many of the assemblages discussed above, apart perhaps from an articulated radius and ulna of an aurochs, Harcourt (1979) did not note the presence of any associated bone groups, complete skulls or other placed deposits. This contrasts with the evidence for placed depositions of bones within many of the late Neolithic pits of a massive timber structure discovered in Dorchester. Most of these bones belonged to pigs, particularly upper limb bone elements. A few of the pits also produced red deer antler (Maltby 1993, 315). Several placed deposits were also recorded in the assemblage from the Thomas Hardye School site in Dorchester (Gardiner *et al.* 2007; Serjeantson 2011, 151). Two pit rings from Conygar Hill produced a total of 40 pig and 21 cattle bones (Bullock and Allen 1997, 193). All the pig bones came from the primary fill of one pit and, although at least two pigs are represented, some of these remains were probably from partial skeletons.

The evidence from Dorset therefore confirms that Grooved Ware assemblages are usually dominated by pig. However, the recent analyses have demonstrated that there can be significant variations in species representation within and between sites, often reflecting the presence of placed depositions of selected individual elements and sometime more complete carcasses of animals. Therefore whether these depositions necessarily accurately reflect typical dietary practices is debatable. The increase in pig consumption on many of these sites is, however, not in doubt and is supported by the frequent presence of pig lipid residues in the ceramics (Crompton *et al.* 2005).

What is often under-emphasised in the analysis of Grooved Ware assemblages is the consistently poor representation of sheep/goat bones. They are absent from several of the Dorset assemblages and in only one case (Mount Pleasant) did they provide over 10% of the counts. This is part of a much wider phenomenon, as the graphs of species representation from a wide range of Grooved Ware sites in England have clearly demonstrated (Rowley-Conwy and Owen 2011, 332–333). Either, as is often implicitly implied, sheep were rarely selected for slaughter at these sites that focussed on feasting on pork and beef, or they were not generally being kept in large numbers at this time. Their poor representation cannot be explained by environmental factors alone. Dorset was not totally dominated by forests at this time. For example, although woodland was still prevalent in valley bottom and floodplain areas, there were also substantial areas of grassland available in the Upper Allen Valley of Cranborne Chase throughout the Neolithic (French *et al.* 2007, 220–226). However, none of the later Neolithic Dorset sites (with or without Grooved Ware) have produced substantial amounts of sheep bones. It therefore seems likely that these open areas of grassland were largely been used for cattle rather than sheep pasture. Although they were imported to the region at the onset of the Neolithic, sheep numbers may have declined after the era of the causewayed enclosures.

Other Late Neolithic, Beaker and Early Bronze Age assemblages

The upper fills of the pit/shaft at Monkton-up-Wimborne produced Late Neolithic lithics but no Grooved Ware pottery, although there were a few sherds of Peterborough Ware (Green 2007a). The faunal assemblage was quite poorly preserved and included many eroded and burnt fragments and a high percentage of loose teeth, which are more resilient to decay than bones. This may partially explain the high percentage of cattle (71%) amongst the 137 identified larger mammal fragments. Pig provided only 15% of the assemblage and, as discussed above, sheep/goat was poorly represented on a non-Grooved Ware site (5%). Red deer was only represented by one bone and six antler fragments and roe deer by a cast antler. Five bones of dog included three forelimb bones probably from the same individual (Maltby 2007b).

With regard to Beaker sites, the Mount Pleasant henge has produced one of the largest assemblages from Britain (Harcourt 1979; Allen and Maltby 2012). The assemblage included high percentages of pig (47% of a minimum of 75 individuals), followed by cattle (24%) and sheep/goat (16%). Bones of wild species also continued to be present in small numbers. Red and roe deer, aurochs, wild boar and fox were represented along with a few bones of duck and geese (Harcourt 1979). Although there is a modest increase in sheep/goat compared with the Grooved Ware assemblage from the site, generally there were no significant changes in species representation and deposition practices.

Several sites on Cranborne Chase have produced animal bones from contexts associated with Beakers, although none of them are large assemblages. A layer near the top of the Monkton-up-Wimborne pit contained a few Beaker and Early Bronze Age sherds along with an inhumation (Green 2007a). The associated bone assemblage is poorly preserved, being dominated by loose teeth. Cattle provided 62% of the identified larger mammal fragments, compared with only 17% pig. Sheep/goat, indeed, outnumber pig, providing 20% of the total. Another cast antler of roe deer and a red deer antler tine were the only records of those species and dog was represented by a single tooth (Maltby 2007b).

The upper levels of the Fir Tree Field shaft were also associated with Beaker pottery along with another small, poorly preserved, bone assemblage. Cattle (13 fragments), pig (5) and sheep/goat (1) were the only species identified (Maltby 2007a, 298–299). Animal bones were also found in four nearby pits, producing a total of 213 identified bones of larger mammals. These included 17 bones of a juvenile sheep/goat in one pit and 27 from a young piglet in another (Maltby 2007a, 299–301). Excluding these associated groups, cattle provided 47% of the identified mammals, followed by pig (40%) and sheep/goat (11%). Red deer was only represented by a burnt antler fragment and roe deer by a shed antler and a loose tooth. However, the assemblages of the four pits varied substantially. Sheep/goat bones (including the partial skeleton and two goat bones) were only deposited in any numbers in one of the pits. Cattle were the most common species in this pit and in one other. Pig elements including the partial piglet skeleton were dominant in a third.

Two pond barrows originating in the Early Bronze Age have been investigated on Cranborne Chase. Tony Legge's analysis of the Down Farm pond barrow established that pairs of elderly cows and sheep had been buried diametrically opposite each other outside the pond barrow (Legge 1991, 72–75). This unique find gave further support to the symbolic role animals often had in and around barrow sites during the Late Neolithic and Early Bronze Age (Serjeantson 2011). Another recently excavated example from Dorset is the Fordington Farm Beaker inhumation, in which the head of an adult male rested on a cattle scapula and his feet on a cattle atlas. Three other filleted cattle scapulae and two scorched cattle humeri accompanied the burial (Maltby 1991b).

The pond barrow excavated at Monkton-up-Wimborne (MUW02; Fig. 27.1) was constructed during the early Bronze Age but some of the depositions continued into the middle Bronze Age (Green 2007b). The faunal assemblage was poorly preserved with most of the surviving elements being loose

teeth. Cattle (51%) and sheep/goat (46%) dominated the assemblage of 271 identified fragments, whereas pig (3%) was very poorly represented. Red deer was only represented by a loose tooth and antler fragment (Maltby *et al.* 2007).

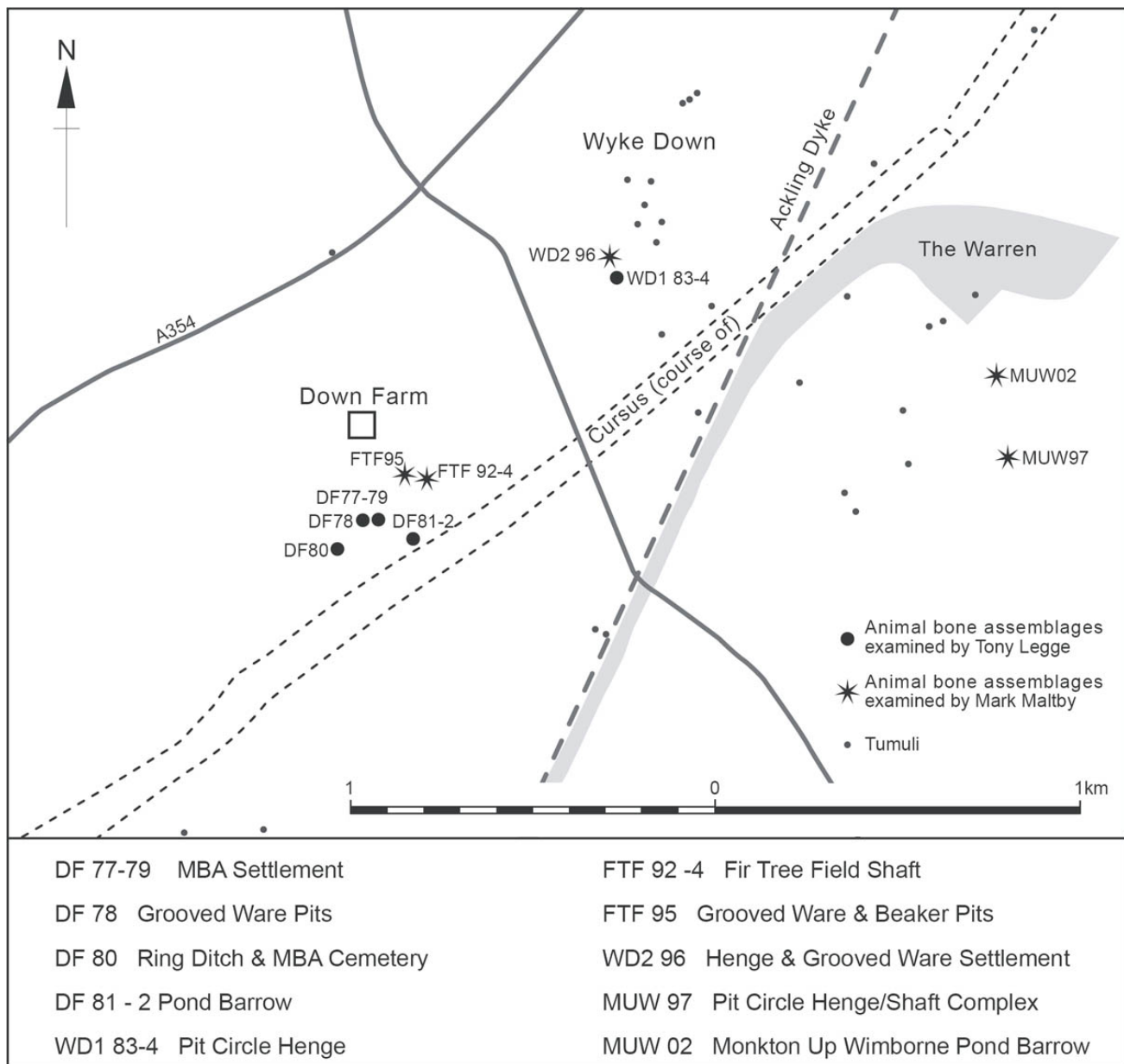


Fig. 27.1. Plan of Down Farm and Wyke Down showing excavated sites and location of animal bone assemblages examined by Tony Legge and Mark Maltby. Illustration by Robert Reed, with permission.

Although the Beaker and Early Bronze Age deposits come from a restricted number of sites of diverse types, there is noticeably less consistency in species representation compared with the largely cattle-dominated assemblages of the earlier Neolithic and the largely pig-dominated Grooved Ware assemblages. Although sheep/goat continue to be poorly represented in some assemblages, they are significantly more abundant in others. This may reflect that this was a period of transition both in the practices associated with consumption and deposition of animals but also in the emergence of sheep husbandry as a significant factor in the regional economy. The assemblages from the later Neolithic and

earlier Bronze Age Dorset sites generally are too small to provide information about exploitation practices beyond very general observations that can contribute to broader discussions (e.g., Legge 1981a; Serjeantson 2011). The continued practice of placing animal deposits in association with both burial and settlement sites demonstrates their symbolic as well as function role to the communities involved.

The later Bronze Age (1500–800 BC)

There are still very few substantial assemblages from the Middle Bronze Age in southern England (Hambleton 2008). Therefore the assemblage from the Down Farm enclosure examined in detail by Legge (1991, 77–90), although of modest size, is again often cited in reviews of this period. Altogether, 368 identified mammal bones were obtained from the enclosure ditch. Cattle (49%) and sheep/goat (43%) elements dominate whereas pig drops spectacularly to 3%. Red deer, horse, dog and roe deer are represented in small numbers (Legge 1991). He demonstrated that sheep/goat were better represented by mandibles and other more robust elements and therefore are underestimated in fragment counts. This is a pattern now widely recognised by other analysts. Legge's tooth ageing analysis showed that around 50% of the sheep were culled by two years of age and that meat production was the major consideration in their husbandry, as he also observed in the contemporary assemblage from Grimes Graves in Norfolk (Legge 1981b; 1981 2007, 82). He also noted and illustrated (Legge 2007, 78) that there was a high (although unquantified) percentage of periodontal disease in sheep mandibles, indicative of poor nutrition. Cattle ageing evidence was limited but there were indications that more calves were represented than in earlier periods, which he used to support his arguments that there was an increase in dairy production during this period, as witnessed at Grimes Graves (Legge 1981a; 1981b) and subsequently on some other later Bronze Age sites (Hambleton 2008, 61–65). Legge also showed that cattle were generally becoming smaller in the Bronze Age in Dorset.

Other Middle–Late Bronze Age assemblages from near Dorchester include Poundbury, which produced 621 identified mammal bones, dominated by mainly adult cattle (72%). However this percentage is inflated by the inclusion of several partial cattle skeletons, possibly from a major butchering episode (Buckland-Wright 1987). Sheep/goat (12%) comfortably outnumbered pig (3%). A single bone of horse was recovered along with modest numbers of red and roe deer.

The Middle Farm site, on the Dorchester By-pass, produced 454 identified mammal fragments from ditches, of which 53% were identified as sheep/goat, and 44% as cattle. Only one horse and three pig bones were recorded (Bullock and Allen 1997, 194). Only sheep/goat (12) and cattle (10) were identified in the contemporary assemblage from Fordington Bottom (Rielly 1997).

The limited Dorset evidence therefore supports the general trends observed for the later Bronze Age period (Serjeantson 2007; Hambleton 2008). Sheep became much more prevalent in an economy that increasingly relied more heavily on enclosed arable farming. With a few exceptions, pig declined to very low levels, at least in chalkland areas, from where much of the evidence has been obtained. Horses were more consistently represented but only in very small numbers. There is evidence from some areas that dairy production of cattle and sheep became more important. Fish bones are usually absent and bird bones only recorded rarely on most non-wetland sites.

Endpiece

There is still much to learn about human and animal interactions in these periods in Dorset. Evidence is

heavily reliant on sites around Cranborne and Dorchester. There are still few samples large enough to merit analysis beyond the basic levels of species representation. However, complex patterns and changes in animal exploitation and deposition have begun to be recognised and these would not be possible if it were not for Tony Legge's innovative analyses and insights into assemblages from this region.

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Reconsideration of the ‘Mesolithic harpoon’ from Westward Ho!, Devon

Sonia O’Connor and Terry O’Connor

On 26 February 1990, a major storm surge caused flooding and coastal scouring along the coasts of Wales and south-west England. Whilst walking with his family on the beach at Westward Ho!, North Devon (Grid Ref. SS 4320 2963), a young boy, Rama Oakley, found an intriguing object where sand had been scoured away in the intertidal zone, uncovering peat and clay (Fig. 28.1). The object was almost discarded as being a piece of wood but Rama’s mother, Amba, a volunteer with the North Devon District Council Rescue Archaeology Unit, placed it in a plastic bag filled with sea water and kept it in the fridge until she could take it for identification to Linda Blanchard, then director of the Archaeology Unit (Amba Oakley, pers. comm.).

The foreshore at Westward Ho! is significant because the lower intertidal zone has remnants of an inundated palaeosurface that has been shown to date to the early Holocene (Balaam *et al.* 1987). Investigations in 1983–1984 yielded stratigraphic evidence of a freshwater wetland environment with associated Mesolithic artefacts. Given that association, and because the object appeared to be made of a hard organic material preserved by waterlogging, it was initially presumed to have derived from the Mesolithic land surface. No *in situ* photograph was taken, but Linda Blanchard’s recollection is that, rather than being stratified within the overlying peat, the object was found lying against the side of a small hollowed out pool in the clay ‘as if it had been deposited by the tide’ (L. Blanchard, pers. comm.) The object was therefore not clearly *in situ* within the Mesolithic remnant, but was out of context on the beach within the vicinity of that palaeosurface.

The object was an elongated piece of a brown, hard and rather fibrous material, at first impression resembling degraded wood. It has a ‘D’-shaped cross-section and bears two groups of notches cut into each of its two longer sides towards the narrower end. Approximate dimensions taken at the time show it to have been 275 mm long, 15 mm wide at one end, tapering to 5 mm at the notched end of the object (Brown 1990). Both ends are broken but the narrower end had been squared off at the tip and remnants of the cut facet survive at the end of the flat side (to the left in Fig. 28.1). Each group of notches is ~50 mm long and separated by a gap of ~40 mm with no notches. The group nearest the tip has ten notches on the left edge and nine on the right: the second group is slightly longer but has only 8 notches on either edge.

The object was received by the Museum of Barnstaple and North Devon (accession number NDDMS 1992.147) and investigated and conserved by Carol Brown, of the Area Museum Council for

the South West Agency Service, in the conservation laboratory of Bristol Museum and Art Gallery. Her Condition Report (Brown 1990) shows that the object was placed in freshly boiled and cooled water. The subsequent Conservation Report (Brown 1991) refers to the taking of a radiocarbon sample, followed 5 months later by adding a fungicide (1% orthophenylphenol) to the storage water then immersion by stages in 25% WS24 acrylic emulsion in deionised water. Neither the Condition Report nor the Conservation Report mention immersion in alcohol. However, a note appended by Brown to the radiocarbon sample in June 1990 says ‘The sample has been treated, just immersed in boiled, filtered water, then put straight into absolute ethanol’ (quoted to the authors by Prof. Tom Higham, 06/06/2013). We understand, therefore, that the first radiocarbon sample was taken before treatment with fungicide or acrylic consolidant, but the possibility of contamination by ethanol remains.

On closely inspecting the object, Brown doubted that the material was wood, and sent microscope slides of the material to botanist Rowena Gale (Royal Botanic Gardens, Kew). After conferring with a colleague from Kew, Gale confirmed that it was not wood nor any other plant material that she could recognise and suggested that it might be of animal origin. Subsequently the material was examined by Vanessa Straker (HBMCE, subsequently English Heritage), John King (Museum of Mankind) and Juliet Clutton-Brock (British Museum, Natural History), none of whom could identify it. In June 1990, Brown sent photographs and the microscope slides to the authors asking whether the material could be horn or antler.

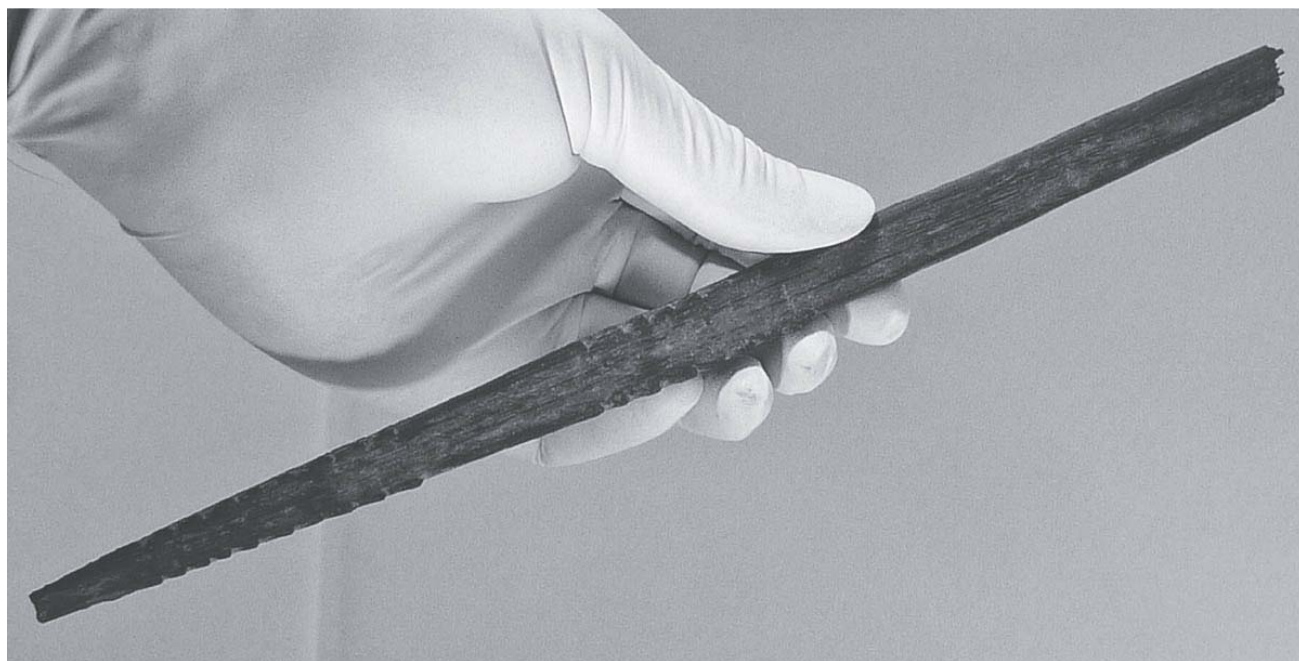


Fig. 28.1. The Westward Ho! 'harpoon' as examined by the authors in 2012. Photo by Sonia O'Connor.

Brown originally described the material as ‘tough, split longitudinally, was slightly transparent and definitely fibrous’. From the detailed photographs and Brown’s description, we concurred that the object was probably made of baleen, an identification that we further justify below, and that it was therefore an exceptional example of an archaeological object made in this unusual material. Baleen is the historical ‘whalebone’, a keratinous structural biomaterial from the oral cavity of filter-feeding whales, in which transverse racks of sheets of baleen fringe the margins of the palate, allowing mouthfuls of seawater to be ‘sieved’ for their content of small prey which are then swallowed. An

important raw material within historical times (O'Connor 1987, 18–20; Lauffenberger 1993; Moffat 2008; Wilkinson 2003; Sorge-English 2011; Stevenson 1907), baleen is, like all keratinous tissues, liable to rapid degradation in most burial environments.

The elongated fusiform shape and notched margins of the object had led to its identification as a harpoon, by analogy with the barbed harpoon points in bone and antler that are well-known from the Mesolithic of Northern Europe (Jochim 2012; Sjöström 2013, fig. 4, p. 16). This identification was consistent with the date presumed from the object's spatial association with a Mesolithic land-surface. Radiocarbon dating was undertaken at the Research Laboratory for Archaeology and the History of Art, Oxford University. This returned a date of 210 ± 60 BP (OxA-3811 Keratin from baleen 1992.147, $\delta^{13}\text{C} = -25.1$ per mil). Given the cetacean origin, and therefore derivation from a marine food-web, it was thought that a marine correction of c. 400–600 years should be applied to this unexpectedly young date, placing the death of the whale in the near future. We return to the question of marine offset below. This unexpected result led to the date being rejected as contaminated, though as we show above, the sample cannot have been contaminated by fungicide or acrylic polymer, and the possibility of contamination by ethanol remains unclear. The object went on display at the Museum of Barnstaple and North Devon labelled as a Mesolithic harpoon (accession number NDDMS1992.147).

In April 2012, the authors examined the object as part of SOC's project *Cultural Objects Worked in Skeletal Hard Tissues*, co-funded by the AHRC and EPSRC Science and Heritage Programme. This research project confirmed the rarity of baleen in the archaeological record. It is unsurprising that baleen has been found preserved by the permafrost conditions on Thule culture sites in the Arctic, or in the remains of seventeenth and eighteenth century whaling settlements in Svalbard but in more temperate climates, keratinous materials are rarely preserved as it is readily destroyed by biodegradation. For instance, despite extensive historical records of baleen processing use and trade in seventeenth and eighteenth century Holland, only three finds of baleen objects are reported from this period. Two off-cuts were recovered from the deep waterlogged deposits in Amsterdam (Rijkelijkhuizen 2009) and a handful of crinoline hoops or corset stays from an eighteenth century privy in Tiel (Bartels 2005, 43). In the UK only one other baleen object is known to have been recovered from archaeological deposits, an unworked fragment from a waterlogged fourteenth–fifteenth century midden deposit at Horse Cross, Perth, Scotland, also identified by SOC (Moffat 2008). The Westward Ho! object was re-examined to reassess the material identification in the light of greater experience with keratinous materials, and to note the degradation characteristics of this material.

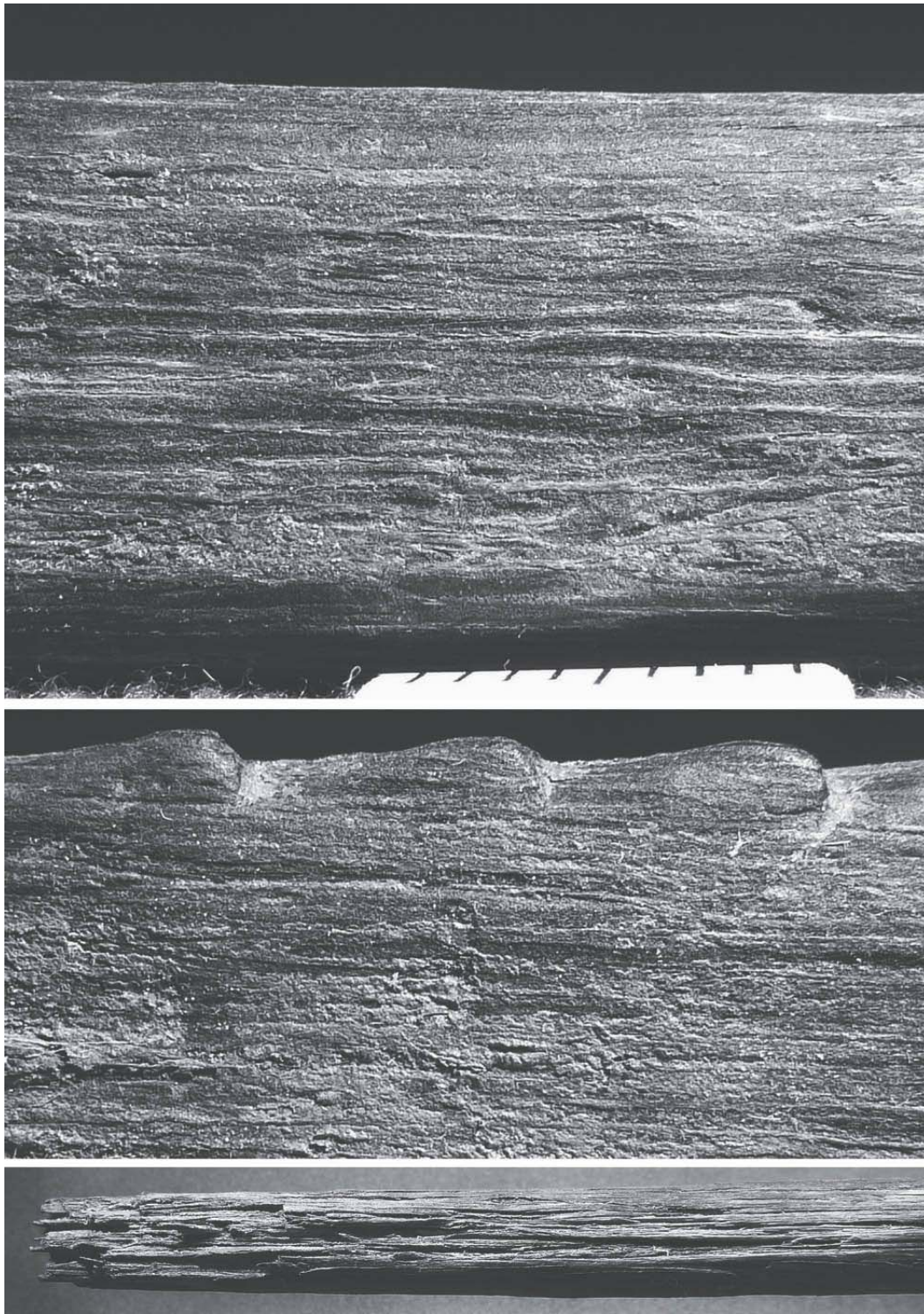


Fig. 28.2. Top: detail of the flat surface. After conservation. Middle: Detail of the second group of notches. After conservation. Bottom: Damage to the curved underside at the wider end of the object. Photos by Sonia O'Connor.

The object was examined by SOC with reflected light microscopy, using optic-fibre lights to vary the angle and intensity of lighting. The microstructure shows tightly packed dark tubules lying parallel to the length of the object within a featureless matrix. These tubules have a diameter of ~ 0.5 mm, with a featureless surface and central lumen now in many cases filled with iron salts, producing a pattern of dark brown and red brown streaks down the length of the object where the working of the

material has cut obliquely through the tubules (Fig. 28.2, top). On the flat surface of the object these tubules are flanked by a more homogeneous, longitudinally fibrous, lamellar material, into which the notches have been cut (Fig. 28.2, middle). The curved back surface of the object cuts through the laminations of the outer material but towards the thicker end the tubules protrude where the cementing matrix has deteriorated (Fig. 28.2, bottom). These are the features of worked and partly decayed baleen (O'Connor 1987, 18–20), and on the basis of macro- and microscale morphology, we were satisfied that the material is baleen.

Baleen plates are a keratinised outgrowth of the dermis and epidermis of the hard palate of baleen whales, the Mysticeti (Fig. 28.3). The main baleen sheets grow at the edge of the mouth and each is flanked by accessory plates, descending in size towards the centre of the mouth. These plates have a tripartite structure; a covering layer of finely lamellar horn-like material surrounding a filling of longitudinal tubules cemented together by intertubular horn (Halstead 1974). At both the labial and lingual edges of the baleen plate the horny covering wraps round the tubular core producing a smooth, curved edge. However on the lingual edge the covering layer is abraded by the tongue, the tubules become free of the intertubular horn and tangle with the tubules from adjacent sheets to form a mesh. The tubules are calcified with bioapatite which stiffens them, despite their constantly hydrated state. The level of calcification and diameter range of the tubules vary from species to species, depending on the porosity and robustness of mesh required by their different feeding habits (Szewciw *et al.* 2010). The relative thickness of the outer horny covering also varies with species as does the colour which can vary from brown/black to a translucent pale yellow/brown, often longitudinally streaked with the darker colours. Young (2012) describes the colour, shape and size of the plates and the relative bristle density and diameters of baleen from different whale species. When worked into objects, the covering layers of baleen can be difficult to distinguish from terrestrial mammal horn (O'Connor 1987, 19–20; Lauffenburger 1993) but where the tripartite structure is retained, this is a diagnostic feature of baleen (Fig. 28.4).

The Westward Ho! object has been cut longitudinally from the edge of a sheet of baleen. Although tubules are evident down the length of the flat surface, on the curved back of the object they are obscured by the horny covering layer for most of its length other than the wider end (Fig. 28.2, bottom). Given the waterlogged condition when found, it is likely that some dimensional changes have occurred to this object, and more precise dimensions would not reflect the original size of the object or the thickness of the baleen sheet from which it was cut so the species cannot currently be identified with any certainty from this fragment. Figure 28.5 (top) shows the break surface at the wider end of the object. Here a tubule can be seen standing free of the curved surface and the circular hole to the right is where a tubule of similar diameter has been pulled out of the intertubular horn matrix. In her letter to the authors and her Condition Report, Brown mentions that prior to conservation this area of the back had become covered in a white/grey fungus during storage that was degrading the material, dissolving the 'matrix' and revealing 'string-like' structures. Although the sites of the samples taken for the botanist and for radiocarbon dating were not recorded, cut marks are visible under the microscope running across this same damaged surface of the curved side close to the broken end (Fig. 28.5, bottom). It is possible, therefore, that the original radiocarbon sample was taken from an area that had been subject to fungal invasion.

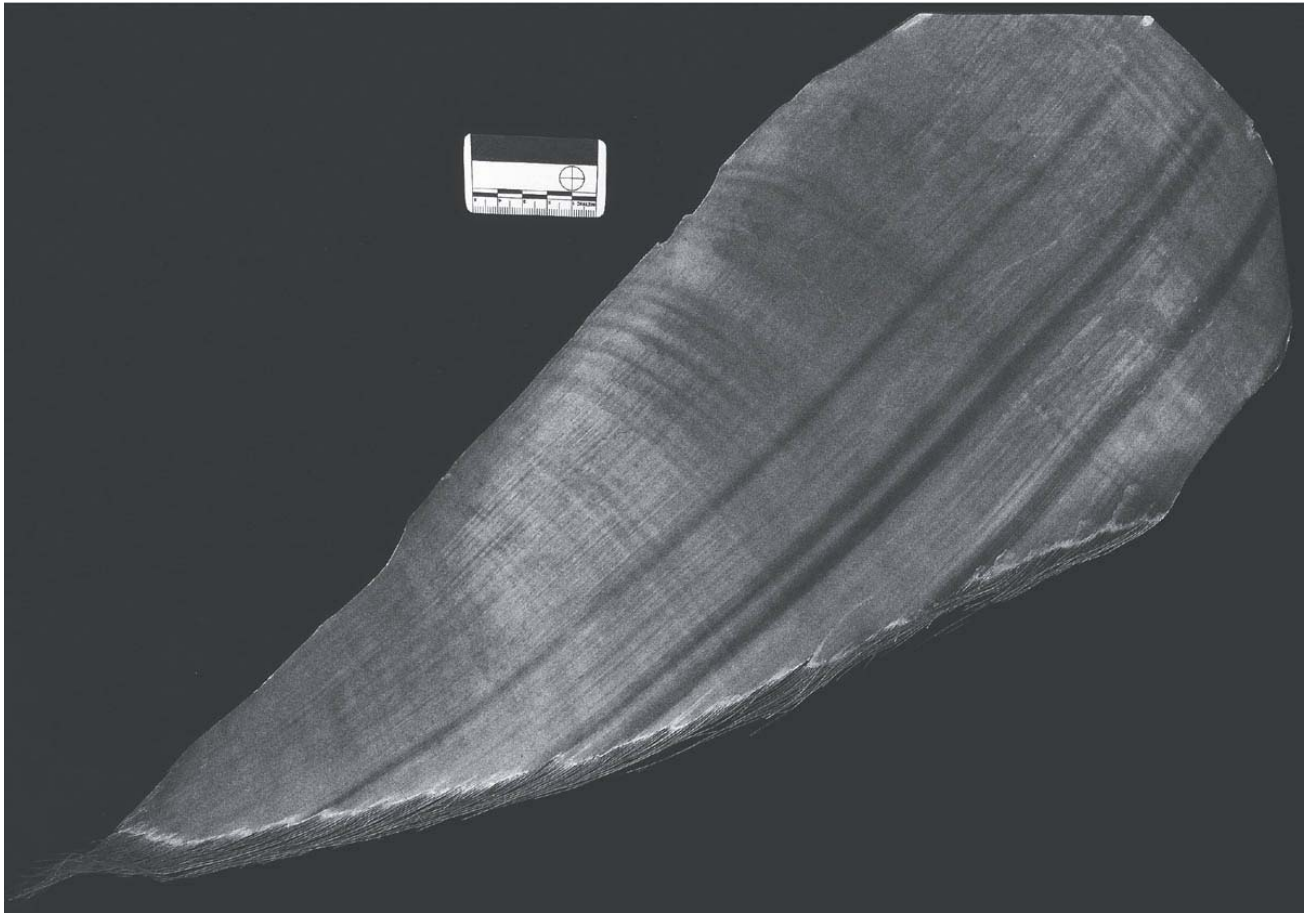


Fig. 28.3. A sheet of baleen (species unknown) from the collections of Hull Maritime Museum. Scale bar is 150 mm. Photo by Sonia O'Connor.

In view of the questions regarding the original radiocarbon date, the specimen was re-sampled, and submitted to the Oxford Radiocarbon Accelerator Unit (ORAU) for AMS-dating. The results confirmed the original date: OxA-27420 002, 179 ± 24 BP, $\delta^{13}\text{C} = -25.4$. Despite the known interventive conservation between taking the first and second samples, they have returned near-identical dates, which suggests that the conservation treatment has not been a significant contaminant. One unexpected finding was the C/N ratio, calculated at 189, rather than the ~ 3.6 – 3.9 expected of fresh proteinaceous tissues such as keratin (T. Higham, in litt.). At the time of writing, we have no satisfactory explanation for this anomaly. Given the consistency of two dates, and the doubtful association of the object with the Early Holocene land surface at Westward Ho!, we accept that the object is unlikely to be of Mesolithic date, and is probably much more recent. The unexpectedly depleted $\delta^{13}\text{C}$ seems inconsistent with a species at a high trophic level in a marine environment. However, markedly variable and sometimes similarly depleted $\delta^{13}\text{C}$ values are seen in other cetacean tissues (Oliver Craig, pers. comm.; Hooker *et al.* 2001; but note Ryan *et al.* 2012). The ‘old carbon’ effect in marine food-webs is most marked close to continental margins, where nutrient upwellings donate old carbon to the base of the food web. In mid-oceanic waters, and especially in the upper part of the water-column, those effects are minimal, with atmospheric carbon fixed by autotrophic plankton forming the food web base. Mysticete whales mostly feed in the upper few tens of metres of the open ocean, and published $\delta^{13}\text{C}$ results for fin whale (*Balaenoptera physalus*) and Antarctic minke whale (*B. bonaerensis*), for example, approach the values seen in this object (Endo *et al.* 2012). We conclude, therefore, that the $\delta^{13}\text{C}$ values are not necessarily out of line with the putative origin of the material,

and that the object is of the order of a couple of centuries old.

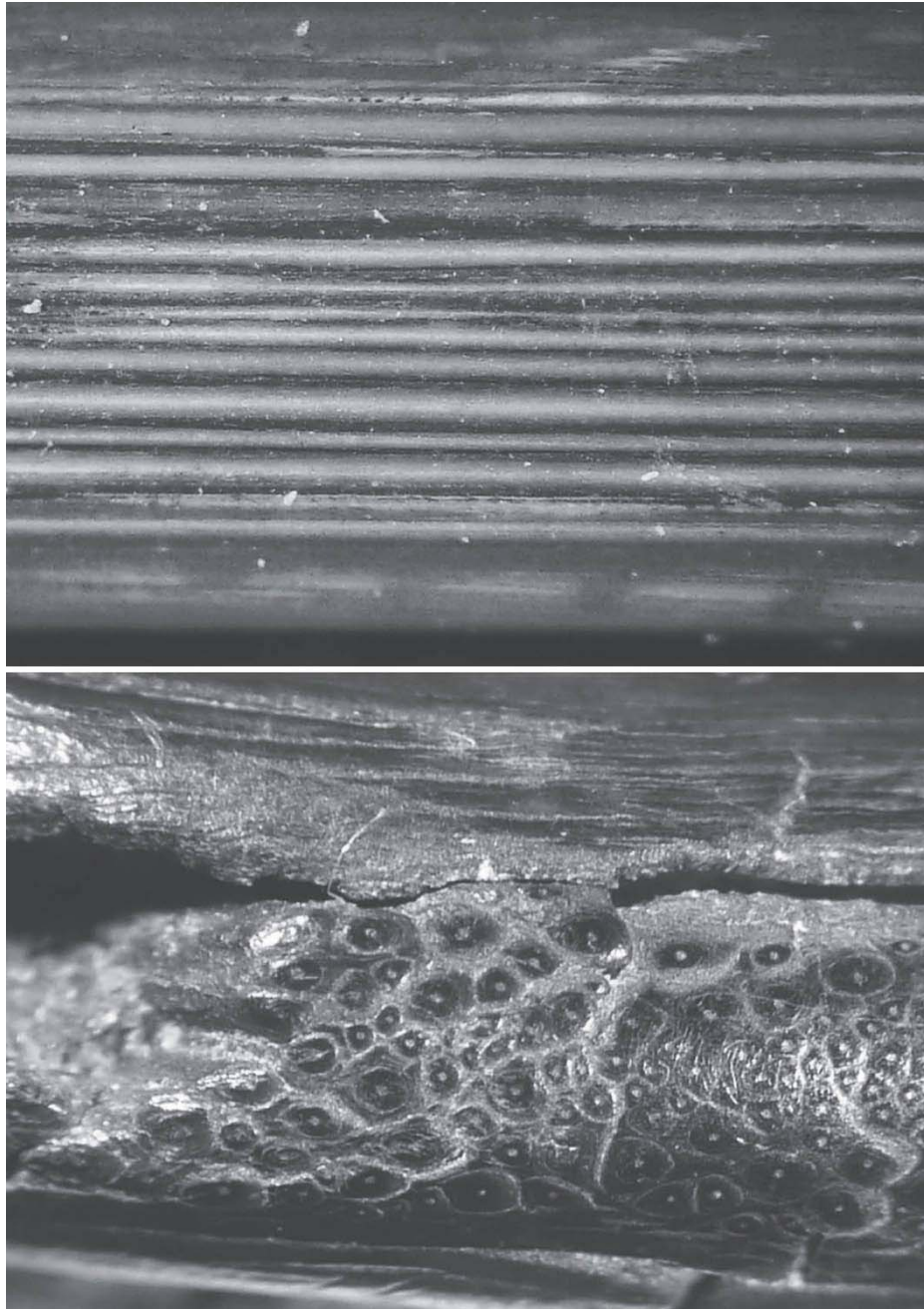


Fig. 28.4. Photomicrograph of worked baleen from Hull Maritime Museum revealing the tripartite structure (HULLMKINCM2005-2401). Top: longitudinal cross-section. Bottom: transverse section. Photos by Sonia O'Connor.

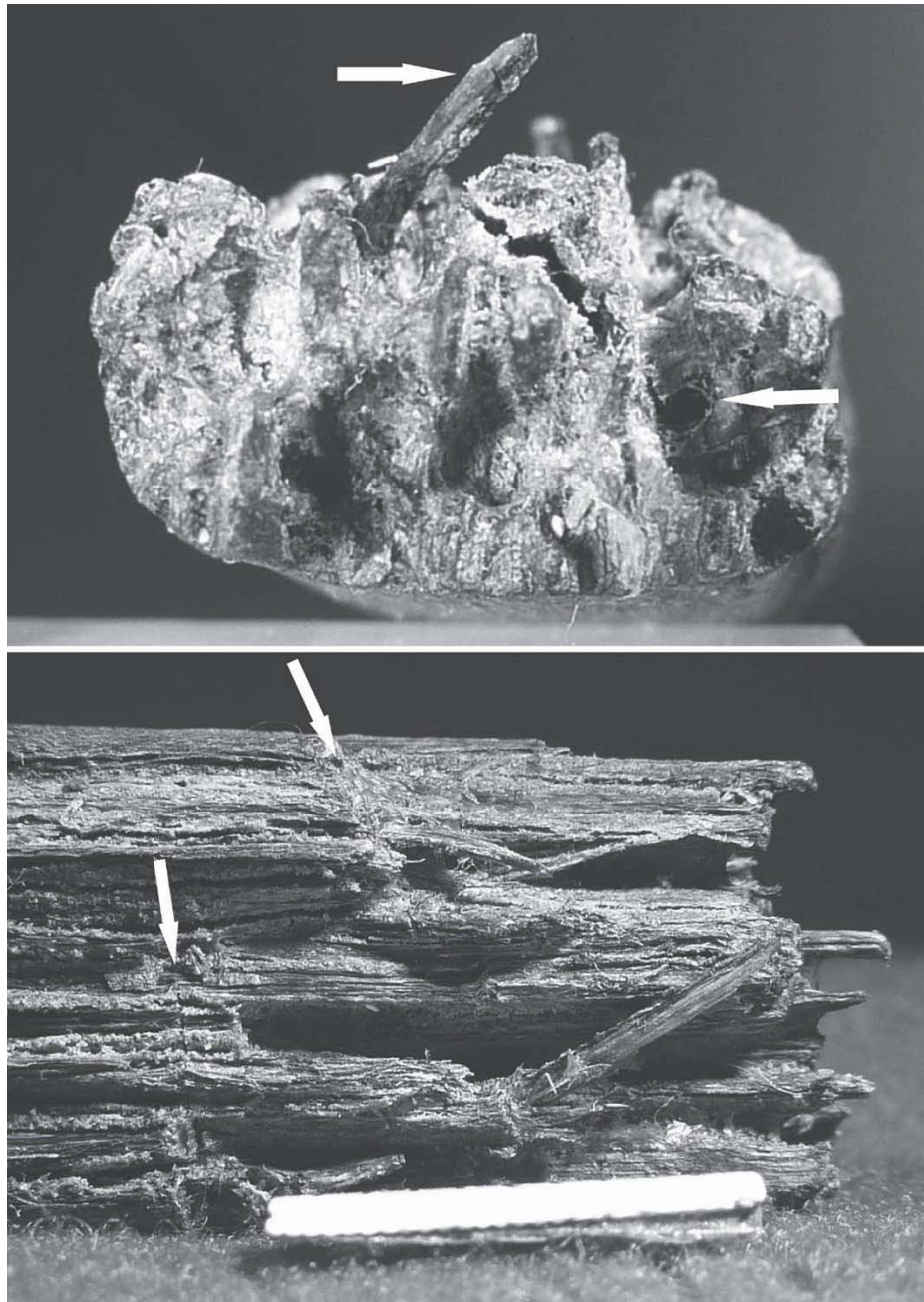


Fig. 28.5. Top: the break surface at the wider end with the curved side uppermost. Bottom: modern cut marks on the underside at the wide end of the object. Photos by Sonia O'Connor.

Whilst the object was under examination, both authors began to doubt its identification as a harpoon. Fresh baleen is somewhat flexible, which is not a good characteristic for a harpoon point. Why make a functional object of a suboptimal raw material when that material is likely to have been much rarer than more suitable bone or antler? Furthermore, the notches would be ineffective as ‘barbs’ on such a harpoon. Barbs, preventing withdrawal of the harpoon point, need to protrude from the sides of the harpoon, as they do on Mesolithic harpoon points made in antler (Elliot and Milner 2010). On the Westward Ho! specimen, the ‘barbs’ are more or less flush with the long sides of the object, and the profile is notched rather than barbed. Close examination of the notched regions showed that the intervening ‘teeth’ are distinctly and evenly worn (Fig. 28.2, middle), as if repeatedly abraded. The un-notched zones on either side of the object are also quite smooth, as if the abrasion continued from

one notched zone across the intervening edge and onto the other notched zone. Elsewhere the surface was not worn to the same extent and on the flat surface a score line still survived from the marking out of the lower edge of the second group of notches.

If not a harpoon, what is this object? Many cultures use notched sticks as a ‘tally stick’, but this object has unequal numbers of notches hard to reconcile with a decimal counting system consistent with the recent historical date. The observed wear pattern could have been produced by rubbing a stick, for example, along the notched edges. This would produce two series of clicks with an intervening pause of similar duration to the pulses of clicks – a ‘krrrk-krrrk’ sound. The object could have had a ‘musical’ function. However, the proposed sound pattern is quite particular and deliberate, as if function-specific rather than musical. In that respect, the object resembles artifacts used in wildfowling in recent centuries, specifically to locate and entrap corncrakes (or land-rail, *Crex crex*). This species was formerly abundant in hay-meadows across northern Europe, and has suffered a recent sharp reduction in numbers and range through habitat loss. Corncrakes are of the Family Rallidae, and resemble a large, brownish moorhen in general shape (Fig. 28.6). Highly regarded as edible game, they have been hunted all across northern Europe, contributing to their decline.



Fig. 28.6. A corncrake (*Crex crex*) in a natural history display at Exeter Museum. Photo by Sonia O'Connor.

Corncrakes are unusual in a number of respects. Their Linnaean name is onomatopoeic, ‘crexcrex’ being an approximate phonetic rendering of the distinctive ‘broadcast call’ of the males. Corncrakes were known by many names in the UK. Macpherson (1897, 425–426) refers to them as landrail and records corn crake and dakerhen amongst their common names. Macpherson also reports

that Gesner, writing in the sixteenth century (Conr. Gesneri Tigurini, 1585, *Medicinae Et Philosophiae Professoris in Schola Tigurina, Historiae Animalium Liber III. qui est de Avium natura*. Francofurdi. First published in 1555), says the English call them 'Ray' or 'Rayl' (Gesner 1585, in Macpherson 1897, xx and 246). Yarrell (1841, 6) also calls them landrail but notes the use of corn crake and meadow crake, and the use of corn creak in Ireland, again alluding to their call. In fact, the reference to *corn* is misleading, as the birds rarely occupy arable land, being more typical of long grassy vegetation in meadows and damp places generally.

Corncrakes are reclusive nocturnal birds. When approached they sit tight on the ground in vegetation cover, using their disruptive colouring and lack of movement as very effective camouflage, and will often 'play dead' when located by a would-be predator (Yarrell (1841, 9). They occupy a habitat in which visibility is severely compromised by vegetation and so communicate by sound rather than by colour pattern or display. The call of an individual bird is stable over long periods but can vary considerably between birds enabling recognition of individuals (Ręk and Osiejuk 2011). Although both sexes call (Ottvall 1999; Cadbury 1980, 204), it is the males that make the rasping broadcast call, predominantly in the breeding season. At this time the males become highly territorial and aggressive towards perceived challengers for territory and mates. Although some birds call occasionally during the day they are most likely to be heard between 11pm and 2am (Schäffer and Mammen 2003, 130) and may call up to 10,000 times in a series of long bouts throughout the night (Ręk and Osiejuk 2010).

The corncrake's call has two syllables separated by a short interval, the first syllable being slightly longer than the second. The interval between the syllables is shorter than the interval between calls. The bird signals the level of its aggression by modifying the length of the interval between calls; the bigger the difference between the intra- and inter-call intervals, the more aggressive the bird. By gauging the aggressiveness of a competing male, the bird will know whether to ignore it, flee or fight (Ręk and Osiejuk 2010). This behaviour has been exploited by wildfowlers. By making a 'crex-crex' call by some artificial means, it is not difficult to get an answering call from a male corncrake that is otherwise invisible in dense vegetation. By controlling the pitch and timing of the call, an antagonistic response can be triggered, causing the corncrake to break cover and to run towards the call, spoiling for a fight. The fowler can then deploy a net, arrow or firearm to acquire a bird that would otherwise be very difficult to locate.

Corncrake lures typically fall into two categories. The corncrake rattle is similar in principle to the traditional 'football rattle', the sound being created by the movement of a flexible wooden lath over a toothed ratchet wheel. In the football rattle the ratchet wheel is fixed to the handle and the lath pivots around it: a quick rotation of the wrist produces the clacking sound. The movement involved would be more likely to send the bird to cover than to induce it to call. The corncrake rattle is deployed in a stealthier manner (Fig. 28.7). The frame holding the tongue doubles as the handle and the fowler rotates the ratchet wheel by drawing it across his thigh (Macpherson 1897 245–246). The 'crex-crex' call is produced by rotating the ratchet twice, with a brief pause. Gloucester Museum has a collection of 15 of these rattles from Gloucestershire, assembled by Dr Oliver H. Wild in the 1930s and '40s and donated by his wife in 1947. Some are by known makers, others are clearly home-made: all are well used, the ratchet wooden teeth showing flattening and polish from wear against the tongue (Fig. 28.7). They vary somewhat in their size, shape and material, and therefore in the precise pitch and timbre of the call, but all would produce a sound sufficient to prompt a response from a corncrake.



Fig. 28.7. A corncrake rattle with box wood handle and wheel and an oak tongue, showing detail of the ratchet mechanism and wear. Collected in 1935 (Gloucester Museum GLRCM F24568). Photos by Sonia O'Connor.

The second type of lure is much simpler, consisting of two strips of hard material, one notched so as to produce the necessary sound when rubbed with the other. Cattle rib was a common material

and Gloucester Museum has an example collected by Dr Wild in 1934 (Fig. 28.8). Boswall (1998) refers to these as ‘Irish’ corncrake lures. Gesner says that Teutonic wild fowlers of his day lured corncrakes by drawing a knife across a dry piece of wood (Gesner 1589 in Macpherson 1897, xx and 245). Nineteenth century accounts refer to these lures as being quite effective, and some even suggest that corncrakes could be deceived by running a thumb-nail or a piece of wood along the teeth of a comb (Macpherson 1897, 245; Yarrell 1841, 7). Given the date, it is likely that these combs would have been made of horn, with properties very similar to baleen.

In order to test the sound properties of the Westward Ho! object, it would have been inappropriate to use the object itself. Quite apart from any conservation and curatorial objections, the degraded state of the baleen would have a marked effect on the sound produced. Instead, a replica was made from horn, fresh baleen being unobtainable given the moratorium on the hunting of whale species. The replica was made by Stuart Fox of the University of Bradford, based on photographs and detailed description supplied by SOC. The replica (Fig. 28.9) is a good match for the original object in size and the depth and spacing of the notches.

On running a piece of horn along the notched edge, a distinct ‘crex-crex’ call was obtained, which could be varied by adjusting the speed of movement and the pressure applied. The match with contemporary recordings of corncrake broadcast calls is quite convincing. The pitch of the replica is a little lower than is typical of most corncrakes. However, corncrake calls, whilst all conforming to the ‘crex-crex’ form, vary and include higher and lower pitched calls. Given the diversity of rattle devices (and combs) that have been used successfully as lures, the performance of this replica is persuasive evidence that the Westward Ho! object would have functioned as a corncrake lure and may have been made as one.



Fig. 28.8. Corncrake lure made from two sections of cow rib. Collected in 1934 (Gloucester Museum GLRCM F24572). Photo: Gloucester Folk Museum.

That leaves the question of its antiquity. We can find no exact parallel for this object. Corncrake lures in museum collections or described in the literature are made in bone or wood, not baleen. Two possibilities must be considered.

First, the object could have originated in the Mesolithic land surface, and could be a unique example of a Mesolithic hunting lure. Mesolithic sites across North-western Europe include examples of systematic harvesting of wildfowl resources (Zvelebil 1995; Van Wijngaarden-Bakker 2002; Yalden and Albarella 2009, 56–71). Off-shore hunting of large whales seems unlikely in the Mesolithic, so procurement of baleen is likely to have been from a stranded whale. However, the two radiocarbon dates make this possibility untenable.

Second, the object is a more recently-made lure, an example of the ‘notched rib’ type made in a different material. Baleen was at its most available in Britain from the late eighteenth–early twentieth centuries, the years of industrial whaling during which all parts of the whale were put to use. Baleen was utilised for purposes as diverse as corset stays, umbrella ribs, upholstery stuffing, brush bristles, cricket bat handles and tape measures (Credland 1995; Dykes 1980; Stevenson 1907). The radiocarbon dates match the historic period during which baleen was most widely available and utilised in Britain.

To sum up, we draw two principal conclusions. First, this object should be removed from any catalogue of Mesolithic objects from Britain, as its association with the palaeosurface at Westward Ho! appears to be fortuitous. It is, instead, a very unusual specimen of ‘folk life’ interest. Second, this is a good example of a preliminary identification based on incomplete information becoming a ‘fact’ that is then used to question subsequent, more objective, evidence. The radiocarbon dates are only ‘archaeologically unacceptable’ if the preliminary identification as a harpoon is accepted, and that identification was based on a superficial resemblance. We conclude that the Westward Ho! ‘Mesolithic harpoon’ is neither Mesolithic nor a harpoon, and all the more fascinating for that.

Acknowledgements

The authors thank the staff of the Museum of Barnstaple and North Devon, particularly Melanie Terrell, Museum Assistant, for providing access to the object and its associated records, and for her hospitality during our visit; Alison Mills, Museums Development Manager, for all her assistance, especially for securing funding for the new radiocarbon date and granting permission for us to publish this find; and Julian Vayne, Learning and Outreach Officer, for putting us in contact with the Oakley family. We thank Amba Oakley, Linda Blanchard, North Devon AONB Manager and Peter Boyd, Museums Officer and Curator at North Devon Museums Service between 1986 and 1993, for sharing their recollections of the circumstances of the discovery, and Carol Brown of Carol Brown Partners, Edinburgh, for additional information relating to its sampling and conservation. We are particularly grateful to Tom Higham, Oxford Radiocarbon Accelerator Unit, for his help in piecing together the documentary trail relating to this object. We thank Sarah Orton, Folk Museum Curator, and David Rice, City Museum and Art Gallery Curator, both of the Gloucester Museums Service, for access to Dr Wild’s collection of corncrake lures. We also thank Stuart Fox, Archaeological Sciences, University of Bradford, for his skill and patience in making the replica, and Laurie O’Connor for making a sound recording of the replica. Funds from North Devon AONB enabled museum visits in search of parallels, the preparation of this report and the new radiocarbon date to be commissioned. Sonia O’Connor’s three-year post-doctoral research project, *Cultural Objects Worked in Skeletal Hard Tissues*, was funded by the AHRC/EPSRC Science and Heritage Programme.



Fig. 28.9. Replica of the Westward Ho! object made in horn. Photo Sonia O'Connor.

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Part VI

Continental Europe and the Mediterranean

Revisiting the animal remains from Neolithic Kalavassos *Tenta*, Cyprus

Paul Croft

Introduction

Sympathising with the mild complaints of a ‘becalmed’ former pupil regarding his rather well-paid job digging up the Romans in Hertfordshire, and his desire to spend the following summer on a working holiday in a foreign land unearthing something earlier, Tony Legge put me in touch with a colleague of his. Ian Todd was putting together a team to begin excavating Aceramic Neolithic Kalavassos *Tenta* (hereafter ‘Tenta’), and thus, through Tony, began in 1976 my long participation in the adventure of Cypriot archaeology.

The Tenta faunal remains were to be studied by Tony, and he did indeed publish preliminary comments on the bones from that first 1976 excavation season (Legge 1978). As I pursued my doctoral research on early prehistoric Cyprus in the late 1970s it became clear that faunal data would be central to it, so Tony generously relinquished to me the task of studying the Tenta material (excavated during five seasons between 1976 and 1984). At that time, he also willingly ceded to me the study of the material from Eddie Peltenburg’s excavations at Lemba *Lakkous* (1976–1982), initiating my involvement (which still continues) with Peltenburg’s various projects in western Cyprus and in Syria. Both Tony and the excavators concerned showed gratifying faith in a near-novice, and with these tasks I took my first uncertain steps in the zooarchaeology of Cyprus. Additionally, Tony allowed me to examine bones (stored beyond the Swiss Lake Villages in the labyrinth that was the old Cambridge ‘Bone Room’) from Trevor Watkins’s 1968 excavation season at the Late (Ceramic) Neolithic settlement of Philia *Drakos* site A. Many years later I examined animal bone from the 1969 and 1970 excavation seasons (all the bone from Philia *Drakos* that could then be located in the storerooms of the Cyprus Museum) and publication of this material (Croft 2010) was greatly strengthened by comparison with Tony’s study of faunal remains from Eddie Peltenburg’s 1969–1973 excavations at the Late (Ceramic) Neolithic settlement of Ayios Epiktitos *Vrysi* (Legge 1982). *Vrysi* had provided the first substantive evidence for an animal economy in Neolithic Cyprus and remains to the present day, along with Philia *Drakos* and recently excavated Paralimni *Nissia* (Croft 2008), one of only three assemblages that contribute significantly to our understanding of subsistence practice in Late Neolithic times (c. 4400–4000 cal BC).

The following re-assessment of the significance of the animal remains from Tenta, presented in affectionate and grateful memory of an opinionated and stimulating teacher and generous mentor,

fittingly takes me back to the very beginning of the lengthy involvement in Cypriot archaeology upon which Tony launched me.

The final report on the Tenta animal remains was eventually published nearly two decades after being completed in 1987 (Croft 2005). The report had not been revised to take account of the huge advances in our understanding of the early prehistory of Cyprus in general, and the chronology of the site of Tenta in particular, that had come about in the intervening years. Dates cited below follow Peltenburg (2003, table 11.6; for a slightly different chronology, see Manning 2013, table A2). At the time the Tenta bone report was written in the 1980s, the site was considered to be broadly contemporary with nearby Khirokitia *Vouni* (but extending somewhat further back in time), and the seventh–sixth millennium BC Khirokitian Culture (then often simply referred to as the Aceramic Neolithic) to which both of these village settlements seemed to belong was widely believed to represent the earliest human presence on the island of Cyprus (McCartney 2005, 178; Todd 1987, xvi, 173; 2005, 381). As a result of new discoveries during the 1990s, however, the Khirokitian came to be understood as representing the Late Aceramic: it is, in fact, the latest phase of a long Early (pre-pottery) Neolithic period, the culmination of a previously undiscovered millennium and a half (later ninth–eighth millennium cal BC) of antecedent development during Cypro-PPNB times (Knapp 2013, 119). The Cypro-PPNB (the Cypriot regional variant of the pre-pottery Neolithic B culture of western Asia, henceforth PPNB) comprises early (EPPNB), middle (MPPNB) and late (LPPNB) sub-periods, each of around 500 years duration. Moreover, it has very recently emerged that prior to the PPNB there existed an even earlier Neolithic (earlier ninth millennium cal BC) Cypro-PPNA period (Manning *et al.* 2010). Falling within what was previously an apparent hiatus, the Cypro-PPNA follows a longer-known Late Epipalaeolithic (tenth millennium cal BC Akrotiri phase).

Regarding the chronology of Tenta specifically, most of the excavated remains may now be seen to date not to the Late Aceramic Khirokitian, as previously believed, but rather to the preceding LPPNB (Tenta periods 4–2, as outlined by Todd 1987, 28–29). Thus, almost all of the animal bones recovered are of LPPNB date (Croft 2005, 348). Basal deposits extending back into EPPNB to MPPNB times were only minimally investigated (Tenta period 5), whilst very little that is preserved at Tenta dates as late as the Khirokitian (Tenta period 1). This chronological revision is based on a more thorough understanding of the Tenta lithic industry, along with reassessment of the radiocarbon dates from the site (which can all now be calibrated) (McCartney 2005).

The purpose of the present article is, finally and for the first time, to place the Tenta animal remains, analysed and reported on so long ago, in their correct chronological and cultural context within the recently discovered early millennia of human presence in the island of Cyprus. Previous discussion of the Tenta fauna gave prominence to comparison with nearby Khirokitia, situated only 6 km to the north-east, because these two village settlements seemed to be (at least largely) contemporary (Croft 2005; Simon Davis (1987, 305–306) similarly included the preliminary evidence from Tenta in his discussion of animal remains from Khirokitia). I interpreted differences between the bone assemblages of Tenta and the far larger settlement of Khirokitia largely in terms of disparate levels of human population in nearly contemporary neighbouring communities. However, now that the revised dating of Tenta places almost all of its faunal remains in the LPPNB, and thus earlier than Late Aceramic Khirokitia, the two assemblages must now be seen to be chronologically successive: developments documented within the Late Aceramic Neolithic economy of Khirokitia should now be viewed as post-dating developments attested during the LPPNB at Tenta. A more chronologically apt comparison for the Tenta material is now to be found with relatively recently excavated material from the long-lived PPNB settlement of Parekklisha *Shillourokambos*, located in the south coastal hinterland some 12 km to the west of Tenta. Specifically, Shillourokambos phases Moyenne A, Moyenne B and

Récente represent the LPPNB (McCartney 2005, 177; Guilaine *et al.* 2011, 586) and thus date, like Tenta periods 4–2, essentially to the second half of the eighth millennium cal BC. The great majority of the finds from Shillourokambos came from Sector I, the subject of a recent very substantial publication (Guilaine *et al.* 2011) and the origin of the Shillourokambos faunal material referred to in the analysis which follows. Roughly two-thirds of the Sector 1 animal remains date to LPPNB and one third to E-MPPNB (phases Ancienne A–C); LPPNB phase Moyenne A alone accounts for more than half of the bone retrieved (Vigne and Carrère 2011, tables 6–7).

Tenta and Shillourokambos

The taxonomic composition of LPPNB faunal samples from Tenta and Shillourokambos (main edible animals only) is documented in Table 29.1, and the same data are illustrated in Figure 29.1. The samples from the two sites are distinctly similar: the very even levels of representation of the main animals at Shillourokambos (all between 30% and 35%) are mirrored at Tenta by only slightly greater variability (28%–39%) within the same rank order of fallow deer (*Dama mesopotamica*), followed by pig and caprines. Cattle, absent from LPPNB Tenta, are present at Shillourokambos, but so poorly represented that their few remains might be residual from earlier times, when they were more abundant (Fig. 29.1). Tony Legge had tentatively suggested that the handful of Tenta bones that he examined might include red deer (*Cervus elaphus*) (Legge 1978), but this proved to be a red herring (Croft 2005, 342). Now, several decades on, fallow deer is still the only cervid that is demonstrably present in prehistoric Cyprus. Whilst it has often been suggested that the deer that were so important to early Cypriot communities were domesticated, it seems clear that they were exploited by hunting (Croft 1991, 64–66; Legge 1982, 82–83), albeit within a system that might be considered as game management (Croft 2002; 2003, 276). The very similar patterns of animal representation at Tenta and LPPNB Shillourokambos suggest a high degree of consistency in subsistence economies in the coastal lowlands of south central Cyprus at this time.

Including specimens of uncertain attribution to period, the bone samples from periods 4 and 2 are each large enough (566 and 635 identified postcranial fragments, respectively) for reliable estimation of taxonomic composition, while that from period 3 (only 131 fragments) is not. Nonetheless, it seems clear that the animal economy did not remain static throughout the half millennium or so of the LPPNB (Table 29.2): the incidence of deer remains fell over time from 57.8% in period 4 to 42.0% in period 2, while that of caprines and pigs rose from 20.0% to 27.5% and from 22.3% to 30.2%, respectively. Evidence for the culling of caprines at younger ages than deer at Tenta underpins the overall conclusion that the former were herded, whilst the latter were hunted (Croft 2005, 355–356 and fig. 75). Faunal change during the LPPNB at Tenta thus reflects declining reliance on hunting and increasing emphasis on caprine and swine husbandry. The expansion of the settlement of Tenta beyond its early (period 4) boundary wall and ditch (Todd 1987, 53–54) implies that an increasing human population underlay these developments, progressively reducing the capability of hunting to provide for human subsistence.

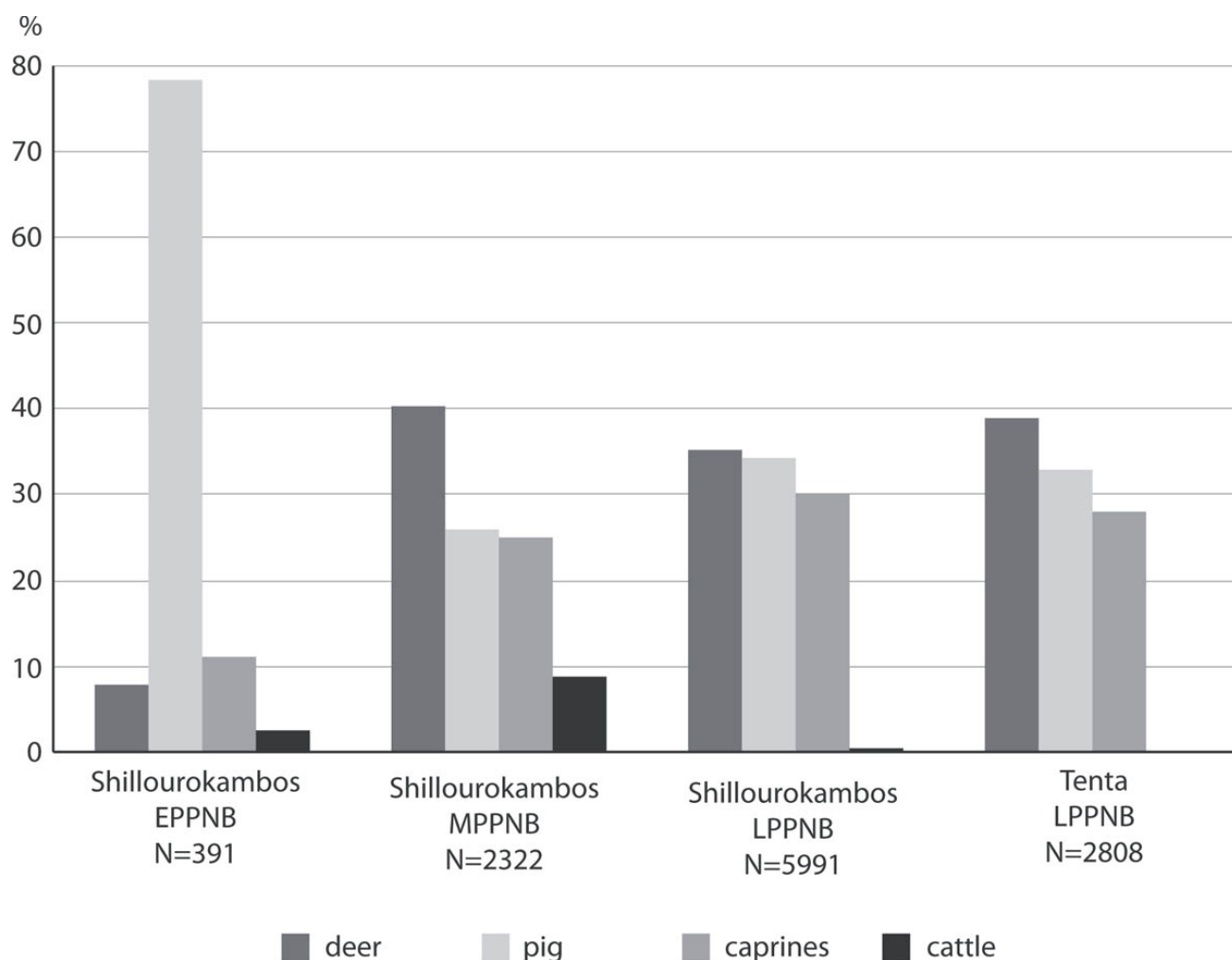


Fig. 29.1. Taxonomic composition of Cypro-PPNB faunal samples from Shillourokambos and Tenta. Proportions for Shillourokambos calculated from total numbers of identified specimens in Vigne and Carrère (2011, table 6).

Table 29.1. Taxonomic composition of Cypro-LPPNB (later 8th millennium cal BC) bone assemblages from Tenta and Shillourokambos

	Fallow deer (<i>Dama mesopotamica</i>)		Pig		Caprines		Cattle		Total
	No.	%	No.	%	No.	%	No.	%	
Tenta (periods 4-2)	1095	39.0	924	32.9	789	28.1			2808
Shillourokambos (Moyenne A+B, Récente)	2101	35.1	2806	34.3	1809	30.2	25	0.4	5991

Data from Croft 2005, table 106c (Tenta); Vigne and Carrère 2011, table 7 (Shillourokambos).

Table 29.2. Taxonomic composition of bone sub-assemblages from Cypro-LPPNB (later 8th millennium cal BC) Tenta and Shillourokambos, and Late Aceramic Neolithic (7th–6th millennium cal BC) Khirokitia

	<i>Fallow deer (Dama mesopotamica)</i>		<i>Pig</i>		<i>Caprines</i>		<i>Cattle</i>		<i>Total</i>
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>	
Tenta									
Period 4	327	57.8	126	22.3	113	20.0			566
Period 3	55	42.0	49	37.4	27	20.6			131
Period 2	267	42.0	192	30.2	176	27.7			635
Shillourokambos									
Moyenne A1	321	43.7	288	39.2	112	15.3	13	1.8	734
Moyenne A2	1408	36.4	1538	39.8	910	23.5	11	0.3	3867
Moyenne B	243	26.0	101	10.8	589	63.1			993
Récente	129	28.2	129	28.2	198	43.3	1	0.2	457
Khirokitia									
Level IV G-D	275	43.7	163	25.9	191.5	30.4			629.5
Level IV C	357.5	39.2	181	19.8	374.5	41.0			913
Level IV B	1181	42.8	535.5	19.4	1044	37.8			2760.5
Level III	189	25.1	116.5	15.4	448.5	59.5			754
Level II	244	10.5	288.5	12.4	1789.5	77.1			2322
Level I	74.5	8.5	86.5	9.9	714.5	81.6			875.5

Shillourokambos figures are based upon all identified fragments (NISP), Khirokitia figures upon NISP for a limited range of elements only, and Tenta figures refer to identified postcranial fragments only, so the three sets of values are not precisely comparable. Data from Croft 2005, table 106c (Tenta); Vigne and Carrère 2011, table 7 (Shillourokambos); Davis 1994, table 1 (Khirokitia).

If not an artefact of the particularly small bone sample for period 3, the apparently fluctuating representation of the pig within the successive faunal sub-assemblages of periods 4, 3 and 2 (Table 29.2) may conceivably denote a more complex situation than that envisaged for hunted deer and herded caprines. Greater complexity might have arisen if the overall pattern for pig is, in fact, an amalgam of data both from the hunting of free-living, feral pigs and from the culling of domestic swine. Although the Tenta pigs were previously considered to have been domestic stock (Croft 2005, 356), it now seems probable that both modes of pig exploitation would have been pursued by the villagers as they sought to offset a growing shortfall in the capacity of deer hunting to provide for their subsistence. If so, increasing emphasis on pig exploitation within an expanding animal economy was apparently insufficient on its own, and an expansion of caprine herding was also deemed necessary.

At Shillourokambos the earliest phase of occupation, Ancienne A, dates between 8400 and 7900 cal BC, equating with EPPNB. In this initial phase limited evidence (391 identified bone fragments) suggests an animal economy dominated by pig (78.3%), with deer (7.9%), caprines (11.2%) and cattle (2.6%) playing comparatively minor roles (Fig. 29.1). Heavy domination of the Shillourokambos EPPNB faunal sample by pig, albeit accompanied by other animals, harks back to Cypro-PPNA animal economies of nearby Ayios Tychonas *Klimonas* (Vigne *et al.* 2011, 11–13; 2012, 8447–8448) and Ayia Varvara *Asprokremnos* in the central lowlands of Cyprus, in which pig was the only large herbivorous animal (McCartney *et al.* 2012, 82) and which seemingly predate the introduction of deer and caprines to Cyprus. Subsequently, in phases Ancienne B–C (MPPNB) at Shillourokambos, higher proportions of deer (40.3%), caprines (25.0%) and cattle (8.7%), and reduced proportions of pig (26.0%), prevail, presenting a pattern of faunal representation that rather more resembles that of the LPPNB (Fig. 29.1).

During the LPPNB at Shillourokambos, a significant decline in the frequency of deer remains is apparent (Table 29.2), as at Tenta. At Shillourokambos, however, this decline is accompanied by a

decrease in pig as well, and counterbalanced by a relatively enormous increase in the proportion of caprines (which almost triples from 15% to 43% of all identified fragments). Evidence for changes in the relative abundance of pig is thus inconsistent between Tenta and Shillourokambos, and pig remains at both sites may well be derived from some combination of herded pigs and free-living feral pigs, which were hunted. The evidence for variability within the LPPNB at the two sites is presented graphically in Figures 29.2 and 29.3, but it must be emphasized that the two sets of values have been generated by slightly different methods, so direct comparisons between them should be approached with caution (see note to Table 29.2). As proposed for Tenta, an increase in human population may underlie these faunal changes at the long-lived, and therefore presumably successful, settlement of Shillourokambos. Taken together, the evidence from these two sites may well reflect a regional pattern for the south-central coastal lowlands of Cyprus in which reduced reliance on deer hunting is offset by increased dependence on herded caprines during LPPNB times.

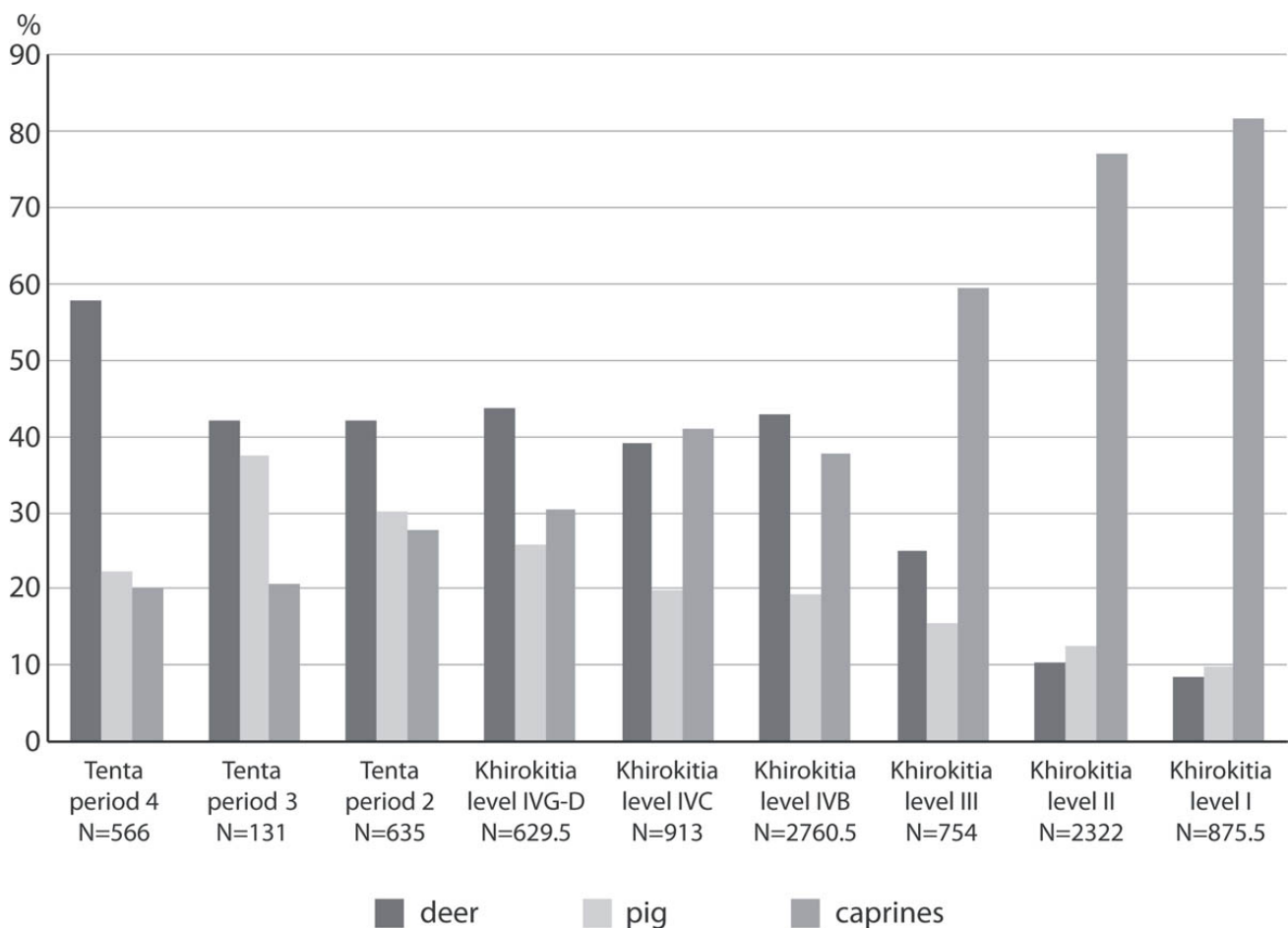


Fig. 29.2. Taxonomic composition of chronologically successive faunal sub-samples from Cypro-LPPNB Tenta and Late Aceramic Khirokitia

Apart from the main, larger animals already mentioned, LPPNB Tenta yielded three bone fragments each of cat and fox, and two of mouse. These two small carnivores, as well as mouse, also occur uncommonly at contemporary Shillourokambos, and all three occur occasionally in earlier levels here also. Dog occurs infrequently in both LPPNB and earlier times at Shillourokambos, while still earlier dog and cat remains are now reported from PPNA Klimonas (Vigne *et al.* 2011, 11; 2012, 8448).

Although dog remains were not identified at Tenta (and were unknown before the Late (Ceramic) Neolithic, at the time when the Tenta report was written – Croft 2005, 360), it nevertheless seems improbable that these hunting and herding villagers did not keep dogs here too. Four fragments of bird bone from Tenta included one that was tentatively attributed to woodpigeon (*Columba palumbus*). The rare occurrence of bird remains is mirrored at Shillourokambos in both LPPNB times and earlier.

Tenta and Khirokitia

Evidence has been presented above (Fig. 29.1) for the strong overall similarity of the LPPNB animal economies of Tenta and Shillourokambos and it has, furthermore, been suggested that developments that took place at the two sites during this period were comparable in some important respects. Khirokitia lies no more than about an hour and a half away on foot from Tenta, and is situated in a somewhat analogous (if slightly more upland) riverside setting. Khirokitia may thus be considered as a successor community to Tenta, at least at a general, regional level. It remains now to evaluate changes in the animal economy that occurred during the occupation of Late Aceramic Khirokitia in the light of those that have been documented for Tenta during the preceding LPPNB period.

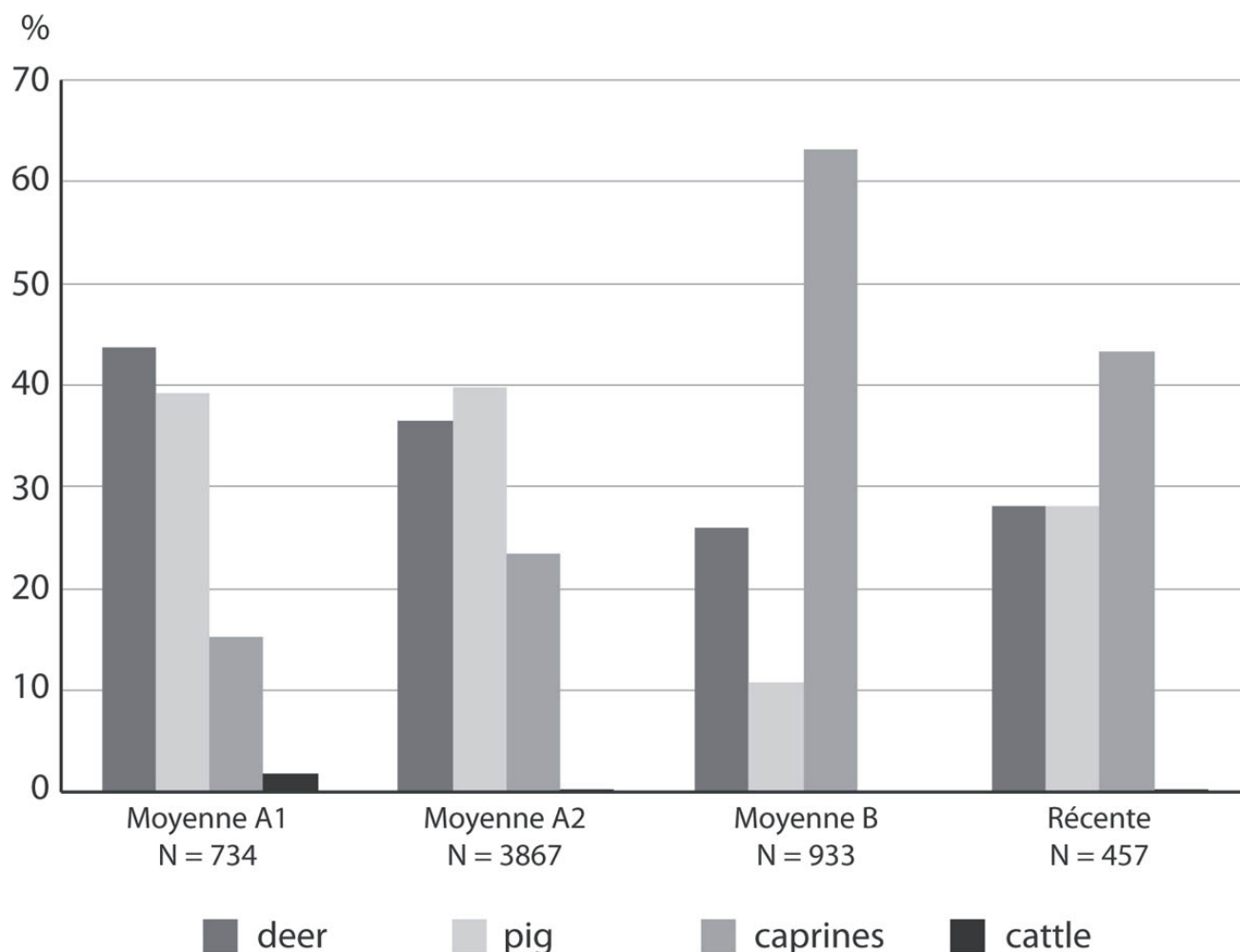


Fig. 29.3. Taxonomic composition of Cypro-LPPNB faunal sub-samples from Shillourokambos

At the time that the ‘final’ report on the Tenta faunal remains was written in the 1980s, only the

first of Simon Davis's three major reports on the bones from Khirokitia (Davis 1984) was available, so the Tenta material could only be compared with Khirokitia Levels III–I. Subsequent reports by Davis (1989; 1994) document faunal material from earlier strata at Khirokitia, and these more recent data should now be incorporated into any comparison between the sites (Fig. 29.2). Of these recent data, the samples from layers G–E are too small to stand alone and so have been combined with the larger layer D sample (Davis 1994, table 1). The combined sample for layers G–D, which may be taken to represent an early stage in the occupation of the village settlement of Khirokitia, included primarily deer (43.7%) with caprines (30.4%) and pig (25.9%) also strongly represented (Table 29.2). Developments within the Late Aceramic animal economy at Khirokitia, through layers IV C–B, and levels III–I successively, included pronounced declines in reliance on both deer and pig, and a huge increase in the significance of caprines. In level I the representation of deer and pig had fallen to 8.5% and 9.9%, and that of caprines had risen to 81.6%. The caprines of both Khirokitia and Tenta were heavily dominated by sheep, with goats accounting for only 17% and 15% of caprines at the two sites (Croft 2005, 353; Davis 1984, 149).

The reduction in the significance of hunting that is denoted by the deer decline at Khirokitia suggests an animal economy under stress. Westward extension of the settlement and the construction of a second boundary wall beyond the first one imply that increasing human population may again have formed the backdrop to this trend (Le Brun 1997, 16). Even if population growth at Khirokitia is not as clear-cut as previously believed (Le Brun and Daune-Le Brun 2009), degradation of the local vegetation and a gradual decline in the productivity of the environs of the site during its long period of occupation offer another possible source of stress. As ever in early prehistoric Cyprus, the extent to which the Khirokitia pigs may have been feral and hunted rather than herded is unknown, but the deer were doubtless hunted animals, and the caprines, emphatically the dominant taxon in numerical terms from Level III onwards, were clearly herded.

At Khirokitia, as argued above for LPPNB Tenta and Shillourokambos, the shift toward greater reliance on domestic stock that accompanies probable human population growth reflects the necessity to adopt an increasingly labour-intensive approach to animal exploitation. Some social ramifications of human populations attaining high densities in the Neolithic of the region have been discussed by Peltenburg (2004), who sees the greater abundance of grave goods at Late Aceramic Khirokitia than at LPPNB Tenta and Shillourokambos as indicative of increasing social differentiation, as 'scalar stress' placed the long-held egalitarian ethos of Cypriot Neolithic society under pressure (Peltenburg 2004, 84–85). The fact that caprine herding came increasingly to dominate the animal economy in the latest levels (III–I) at Khirokitia indicates that the degree of intensification here far exceeded that in LPPNB times at Tenta and Shillourokambos. The Khirokitia level I evidence reflects, essentially, a caprine animal economy, with relatively minor inputs from deer hunting and the exploitation of pigs, by whatever means. Intensification of the animal economy, linked to growing populations in village settlements, seems apparent throughout LPPNB and Late Aceramic times, at least in the south-central coastal lowland region of Cyprus, and the final demise of the village of Khirokitia, and possibly of the Khirokitia culture island-wide, is most likely linked to stresses inherent in these processes (Peltenburg 2004, 84–86).

Khirokitia was clearly an exceptionally large settlement, possibly the largest, of its period in Cyprus, and it is clear that not all Late Aceramic settlements followed a similar economic trajectory. At Cape Andreas *Kastros*, a far smaller coastal settlement located on the tip of the Karpas Peninsula that forms the 'panhandle' on the north-east of Cyprus, the faunal evidence tells a quite different story. Although the Cape Andreas bone sample is admittedly relatively small (total number of identified specimens 505.5), substantial increases in the representation of deer and pig are strongly suggested

throughout five consecutive occupation layers (II–VI), accompanied by a massive decline in the proportion of caprines (mainly goats) (Davis 1989, table 4b). The meaning of these faunal trends, which run contrary to those exhibited by Khirokitia, can only be a matter for conjecture – over-hunting of a feral goat population is one possibility, de-intensification in exploitation of terrestrial resources by a community heavily reliant on the sea (Croft 1991, 69) is another – but ultimately developments here must reflect the smaller size of the human community operating out of Cape Andreas. Following the disappearance of the Khirokitia culture around 5200/5000 cal BC, there is an apparent (and still unexplained) hiatus of possibly half a millennium duration (Manning 2013, 507–508) during which the human population of Cyprus may have been reduced and was presumably more dispersed across the landscape, pursuing a more mobile lifestyle (Knapp 2013, 157–158). The Late (Ceramic) Neolithic sees the re-appearance of village settlements with animal economies that typically rely mainly upon deer hunting, and heavy reliance upon deer persists throughout Chalcolithic times (fourth–later third millennium cal BC) and beyond (Croft 2008, 106–108; 2010, 134–136).

Conclusion

Almost 30 years ago, during the infancy of our understanding of Neolithic Cyprus, it seemed that economic differences between Khirokitia and Tenta might be explained primarily in terms of the greater demands placed upon the subsistence system by the considerably larger human community at Khirokitia (Croft 2005, 359). The orthodoxy of the 1980s severely inhibited the view that the two settlements might be other than contemporary, with Tenta largely predating Khirokitia, even though the radiocarbon dates strongly hinted that this might be the case. The observation made at that time ‘that the closest comparison in faunal patterning is between Period 2 (the latest for which a useful sample is available) at Tenta and Level III (the earliest for which a useful sample is available) at Khirokitia, suggests that the occupation of these two Aceramic sites might have been essentially successive rather than contemporary’ (Croft 2005, 359) may, with hindsight, be viewed as apt indeed. This comparison is graphically illustrated in Figure 29.2. Further to the faunal and chronometric evidence, it was suggested that architecture, other material culture, and burial rites would also allow for the occupation of Tenta from a significantly earlier date than Khirokitia (Croft 2005, 357–359). However, in deference to the prevailing (1980s) orthodoxy, all of these suggestive strands of evidence led only to the equivocal conclusion that ‘Whilst a chronological disparity between these two Aceramic settlements must remain a strong possibility, differences between them are not sufficiently great to render precise contemporaneity inconceivable. Only a finer-grained appreciation of their chronology would offer a solution to this problem’ (Croft 2005, 359). The required enhanced appreciation was only attained following the passage of two decades and this, along with additional evidence from Khirokitia and Shillourokambos, has enabled a long overdue reconsideration of the Tenta faunal assemblage finally to be presented here. If community size still appears to be the key variable in explaining differences between the animal economies of Tenta and Khirokitia, this factor may now at least be more satisfactorily considered in the context of a demonstrable chronological disparity between the sites, and of long-term regional economic and demographic trends.

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Neolithic subsistence at Vela Špilja on the island of Lošinj, Croatia

Suzanne E. Pilaar Birch

Prologue

Upon my arrival as an MPhil student to the Grahame Clark Laboratory for Zooarchaeology in the Department of Archaeology at the University of Cambridge, Tony Legge cut an intimidating figure in the corner of the room. At first, as I worked on a faunal assemblage including unfamiliar wild European species like red deer and boar, I would approach him hesitantly, usually asking his opinion on a mystery bone fragment. But I needn't have been so cautious, as I think anyone who knew Tony would agree; and throughout my MPhil and PhD he would often offer helpful articles or anecdotes and became a firm friend.

I was initially drawn to writing about a topic inspired by one of our many conversations in the lab with a more historical bent, but in the end opted to contribute a paper derived from my MPhil research, which would not have been possible without Tony's support.

Introduction

The Adriatic basin is especially important in tracking the spread and adoption of domestic animal and plant species as these aspects of the 'Neolithic package' moved from Southwest Asia into Europe along the Balkan interior and coastline in the early Holocene (e.g. Chapman and Müller 1990; Legge and Moore 2011). Arguably one of the most important events in human history, this major shift in subsistence from consumption of solely wild resources to domestic ones had a drastic impact on mobility, culture, and technology at the start of the Neolithic. Did local communities of mobile Mesolithic foragers adopt domesticates from surrounding regions, or were these people replaced by incoming Neolithic pastoralists? What role would hunting have played in this transition?

The island of Lošinj lies off the coast of Croatia in the northern Adriatic Sea and would have been a high point on the Great Adriatic Plain during the Last Glacial Maximum. Rising sea level throughout the Mesolithic separated Lošinj from the mainland, and it would have become an island by the Early Neolithic (Fig. 30.1). The cave site of Vela Špilja (VSL) is located 268 m above sea level on the western face of the mountain Osorčica. The geographical setting of the cave and long history of human settlement provide the opportunity to investigate questions of continuity and disruption in patterns of consumption during the Mesolithic–Neolithic transition. The site is especially interesting as

there is accompanying evidence of cultural change in the form of stone tool technologies and the 'arrival' of pottery and domesticates. In addition, the site is situated above a rapidly changing coastline that affected the surrounding ecosystem and the role of humans within it (cf. Miracle 2007; Pilaar Birch and Miracle 2015; in press).

The initial Neolithic in the region coincides with both global and regional climatic and environmental change, which would have significantly impacted on human subsistence and mobility decisions. Mean annual temperatures across Europe increased significantly in the early Holocene (Davis *et al.* 2003) and this warming is reflected regionally by changes in vegetative cover (e.g., Schmidt *et al.* 2000). Locally, a layer of massive colluvial discharge found within a sediment core taken in the Istrian peninsula just north of Lošinj is believed to have been deposited during 'a period of rapidly changing climate' at the Mesolithic–Neolithic transition dated just prior to 7000 years cal BP (Balbo *et al.* 2006, 115). These changes coincide with the initial Neolithic at the site, which is amongst the earliest in the region with a secure date of 7926–8018 cal BP (using OxCal IntCal13; 7,134±37 BP, OxA-18118; Forenbaher *et al.* 2013). There is an additional, later date for a level characterised as 'Early/Middle Neolithic' of 6955–7170 cal BP (Pilaar Birch *et al.* 2016). In contrast, published dates on charcoal for the Mesolithic at VSL, associated with wild fauna and terrestrial snails, range from 10,651–10,868 and 11,160–11,314 cal BP (Forenbaher *et al.* 2013). Based on a recent comprehensive review of dates for the Neolithic of the eastern Adriatic, it has been suggested that a potential early, rapid expansion along the coast excluded crop cultivation but included pottery, the introduction of domestic sheep and goat, and the practice of herding, while a second, later stage included the establishment of farming villages; in Istria and the Kvarner Gulf, this first stage may have lasted longer than at sites further south, where farming may have been established relatively soon following the 'arrival' of the initial Neolithic (Forenbaher *et al.* 2013). This model suggests that there may be some potential for the detection of mixed subsistence strategies in the 'first wave' of Neolithisation in the region, followed by a potentially more homogenous signal in the later periods when crop cultivation becomes integrated into the economy.

Research aims

This paper resulted from a larger project on changing subsistence on Lošinj in response to local and regional environmental fluctuations from the end of the Palaeolithic throughout the Neolithic. The current discussion will focus on the nature of change in subsistence patterns in the earliest Neolithic at the site. If there is abrupt change in the composition of the faunal assemblage, then this may suggest that there has been a replacement of the Mesolithic forager population by Neolithic pastoralists, whereas the inclusion of wild species in the diet may support the adoption of some elements of the 'Neolithic package' by local people. Furthermore, differences in carcass processing may also inform us on the changing role of hunting and wild animals at the site. To this end, I will first characterize and discuss changes in the faunal assemblage from the Mesolithic to the Neolithic, as well as compare carcass processing between the Mesolithic and Neolithic and between wild and domestic species in the Neolithic.

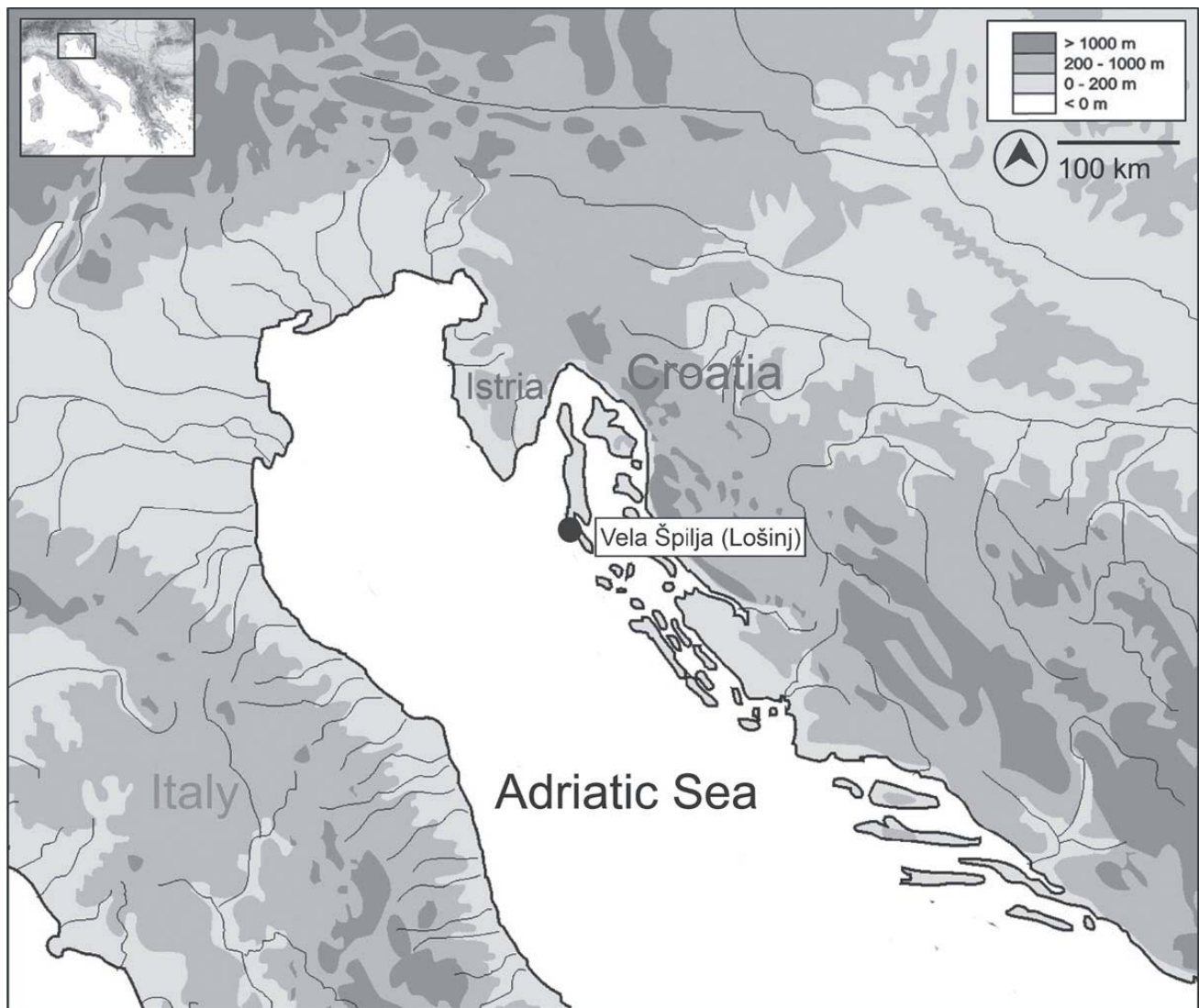


Fig. 30.1. Location of Vela Špilja Lošinj (after Forenbaher and Miracle 2005).

Materials and methods

The most recent excavation of Vela Špilja took place in 2004 (Miracle *et al.* 2004). Two trenches were opened off the original exposed profiles, and a third 1×1 m trench was excavated near the cave mouth. The main chamber of the cave is 26 m long. The terrain below it is rocky and steep, making access to the sea difficult. All excavated sediment was dry-sieved using a 3 mm mesh. Faunal remains included in the Number of Identifiable Specimens (NISP) were determined using the following criteria: all teeth and tooth fragments; fragments longer than 5 cm; any fragment with part of articulation, including vertebrae; long bone shafts with nutrient foramen and/or prominent muscle attachments; any fragment with cut marks or polish/abrasion; proximal ends of ribs; and cranial fragments with external morphology identifiable to cranial bone. Unidentifiable specimens consisted of highly fragmented long bone shaft or nondescript cancellous bone. The Neolithic assemblage totalled 607 (37%) bones identifiable to element and species, while 121 (7%) were identifiable only to size class, and 937 (56%) were unidentifiable. In the Mesolithic, 44 (20%) were identifiable to element and species, 33 (15%) to size class only, and 145 (65%) were classified as unidentifiable.

Changes in faunal composition

In order to identify possible dietary shifts occurring at the site through time, the faunal assemblage must first be characterised. In the Mesolithic, remains of wild chamois and ibex, which would have been especially well adapted to the rocky terrain surrounding the cave, make up approximately 35% of the assemblage (Fig. 30.2). This is followed by hare, composing about 25% of the assemblage. Fragments of red and roe deer bones comprise another 20% of the assemblage. Remains from wild boar (10%) and fox (5%) are also present. As the nature of the data is that of a palimpsest, the presence of fox is most likely due to natural causes rather than human exploitation as a foodstuff. Due to the presence of cut marks and burning, and the larger sample size of prey species, it is concluded that humans, rather than other carnivores, are the primary agent of accumulation in the cave.

In stark contrast to the Mesolithic, sheep and goat dominate the assemblage in the Neolithic. There is very little change in species representation throughout, with a slight increase in caprines from the earliest Neolithic (94%) to almost 99% by the end of the sequence (Fig. 30.3). In many cases, it was not possible to distinguish between sheep and goat remains due to similarities in skeletal morphology, especially when using teeth and mandibles (Zeder and Pilaar 2010). Post-cranial remains were separated based on previously established criteria (Boessneck *et al.* 1964; Barone 1976; Prummel and Frisch 1986; Helmer and Rocheteau 1994; Zeder and Lapham 2010), but despite this, a majority of the sample remained classified as sheep/goat. The categories of sheep, goat, and sheep/goat have been combined and are presented as caprine on the graph below. Roe deer, pig (wild or domestic) and hare remains are present in the Early and Middle Neolithic at the site, but disappear entirely by the Late Neolithic. Fox is the only species present throughout the Neolithic sequence, suggesting these animals may have used the cave as a den in times of abandonment. The higher percentage of deer and hare in the Early Neolithic are tempting ‘evidence’ of inclusion of wild game in the diet at this time period. However, the small sample size of non-caprines (n=31) suggests that these remains may be present in the cave as a result of natural agents of accumulation rather than human agency.

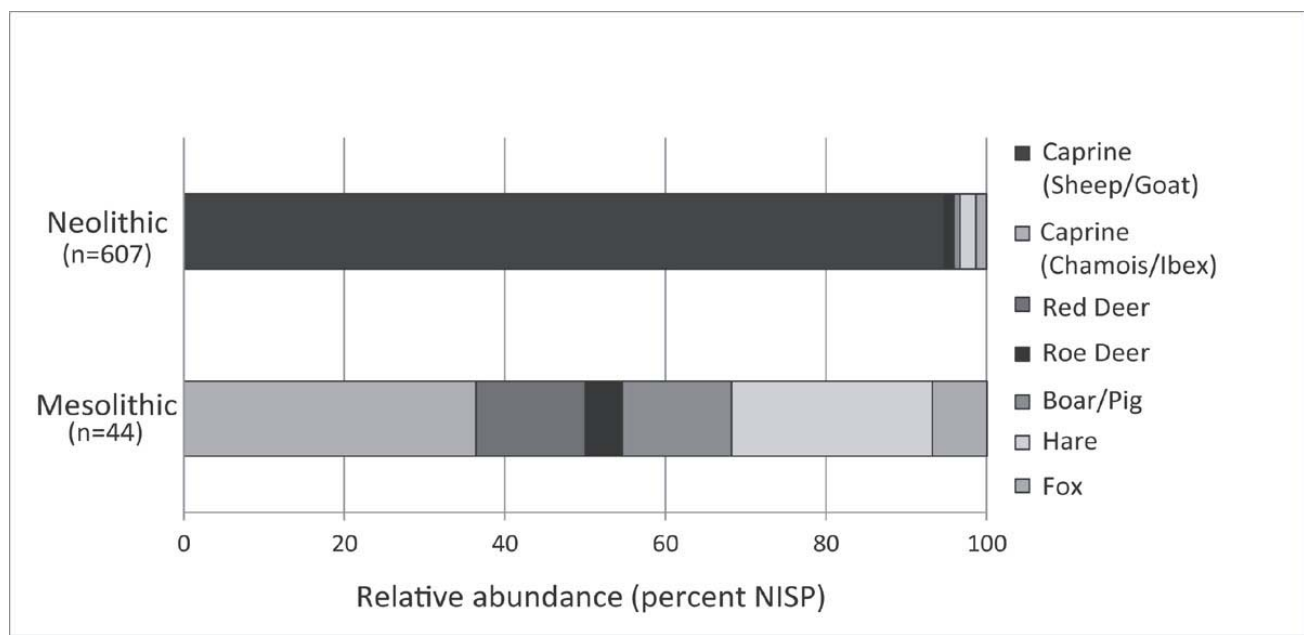


Fig. 30.2. Change in faunal composition from the Mesolithic to Neolithic at Vela Špilja Lošinj.

The data up to this point suggest a break in tradition from foraging to a completely different type of subsistence economy even in the earliest Neolithic. As a result of rising sea level and subsequent decrease in biomass, there would probably have been a decline in the richness and density of prey species. This could have resulted in abandonment of the cave at the end of the Mesolithic and re-use at the beginning of the Neolithic with the arrival of a new group of pastoralists with a sheep-goat economy.

Hunting and carcass processing

Sheep and goat were clearly the economic mainstay of people using the cave during the Neolithic, but how did they contribute to the diet? Were they bred for their meat, dairy products, or both? Did people continue to supplement their diet with wild resources? How did the use of caprids in the Neolithic differ from that in the Mesolithic?

Based on body part representation for the Neolithic, it seems like whole animals were dying at the site, as most body parts are fairly well represented by percent NISP (Fig. 30.4). Tibiae and metapodials are by far the most abundant appendicular skeletal elements in the assemblage, comprising over 10% in both cases, and femora are also very common. Femora are considered high-utility elements and yield desirable amounts of flesh and marrow; metapodials less so as they yield some marrow but little meat (e.g., Lam & Pearson 2005). The occurrence of splitting and spiral fractures on a number of the metapodials suggests there may have been more intensive processing of lower-utility skeletal elements for marrow and fat. Thus the sheep and goat at this site were probably being consumed. However, there were also a large number of foetal and neonate remains in the assemblage at all levels. This could be indicative of a spring use of the cave, when the sheep and goat would have been penned inside for lambing and used for their milk. At this point it is easy to imagine a scenario in which the cave was used in more than one season, and different products consumed at different parts of the year.

If this was the case, what role, if any, did wild resources play in the Neolithic subsistence economy? The sample size for non-caprines is very small. Figure 30.5 demonstrates that there is no convincing evidence for human consumption of these wild animals, which are best represented by metapodials, ribs, and skull fragments. These elements occur in high frequency in the mammalian skeleton and are susceptible to high fragmentation rates, supporting the case for natural accumulation in the cave rather than targeted hunting by humans. This suggests the subsistence economy can be assumed to be wholly based on sheep and goat meat and perhaps secondary products, not supplemented by wild game, and again reinforces a complete break in tradition from the subsistence economy of the Mesolithic.

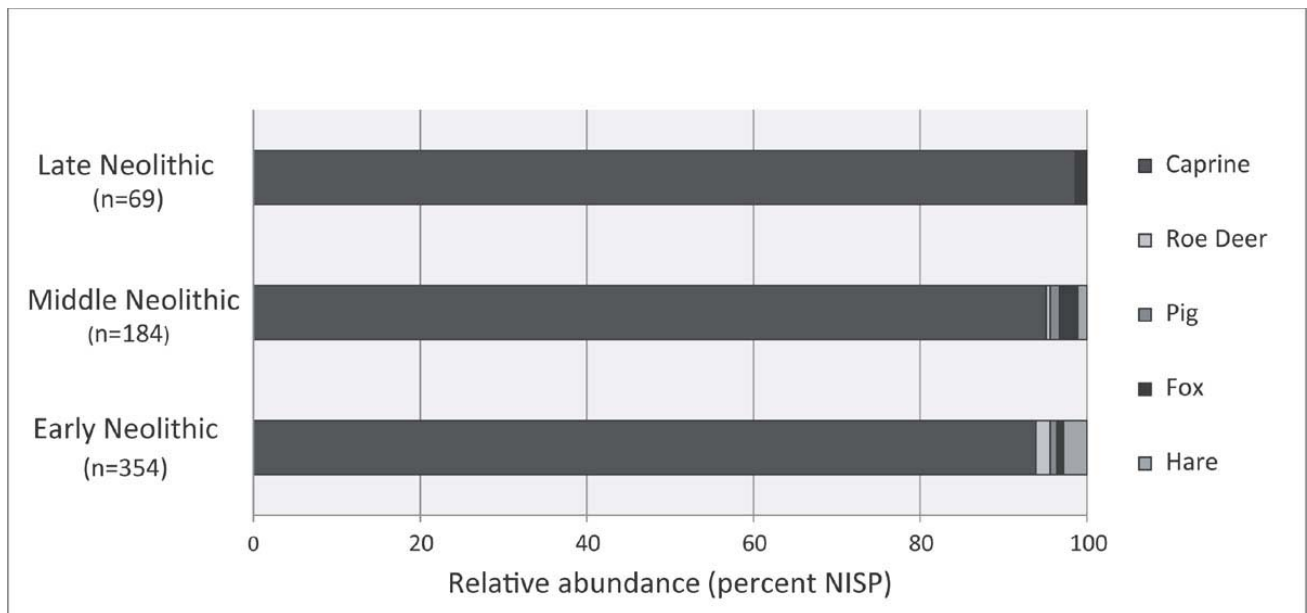


Fig. 30.3. Change in faunal composition through the Neolithic at Vela Špilja Lošinj.

Unfortunately, although sheep/goat and chamois/ibex make up the majority of the Neolithic and Mesolithic assemblages, respectively, a comparison of carcass use of these species, which fill a similar niche in terms of flesh yield per element, is not possible. The prevalence of mandible and skull fragments and dense skeletal elements such as calcaneus, metatarsals and phalanges suggests that, in addition to potential element transport by humans or animals, diagenetic biases have influenced the assemblage to a significant degree, resulting in a sample size too small for an interpretation regarding carcass processing.

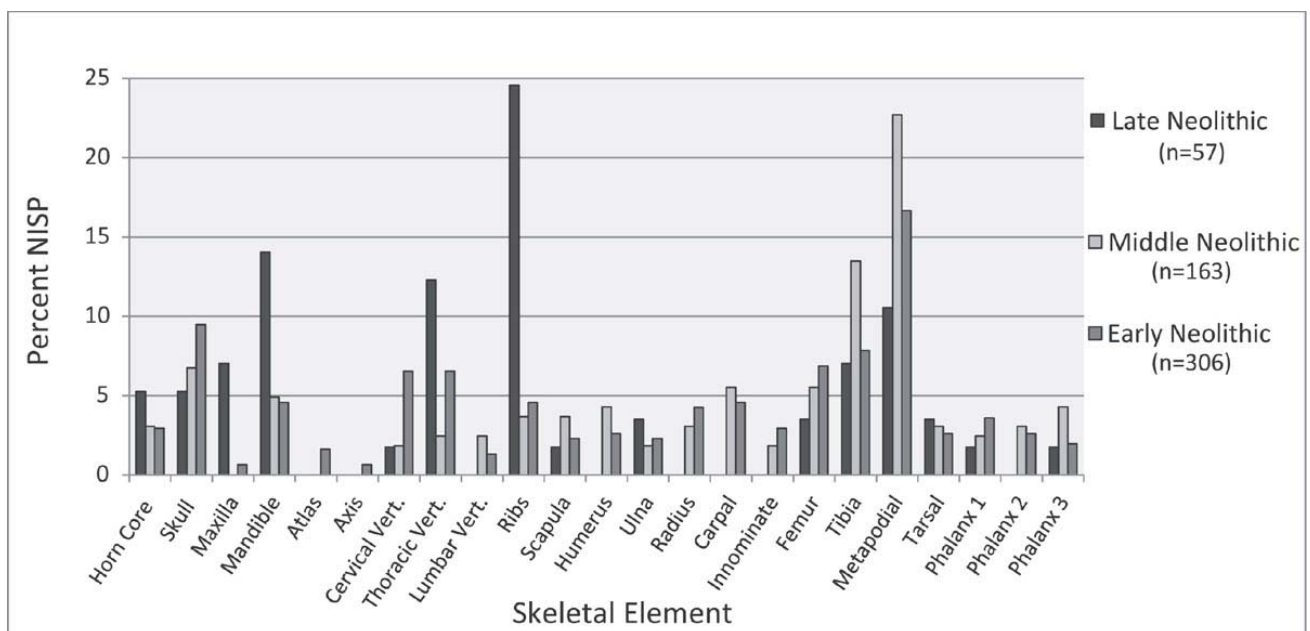


Fig. 30.4. Body part representation (excluding teeth) for caprines (sheep and goat) through the Neolithic at Vela Špilja Lošinj.

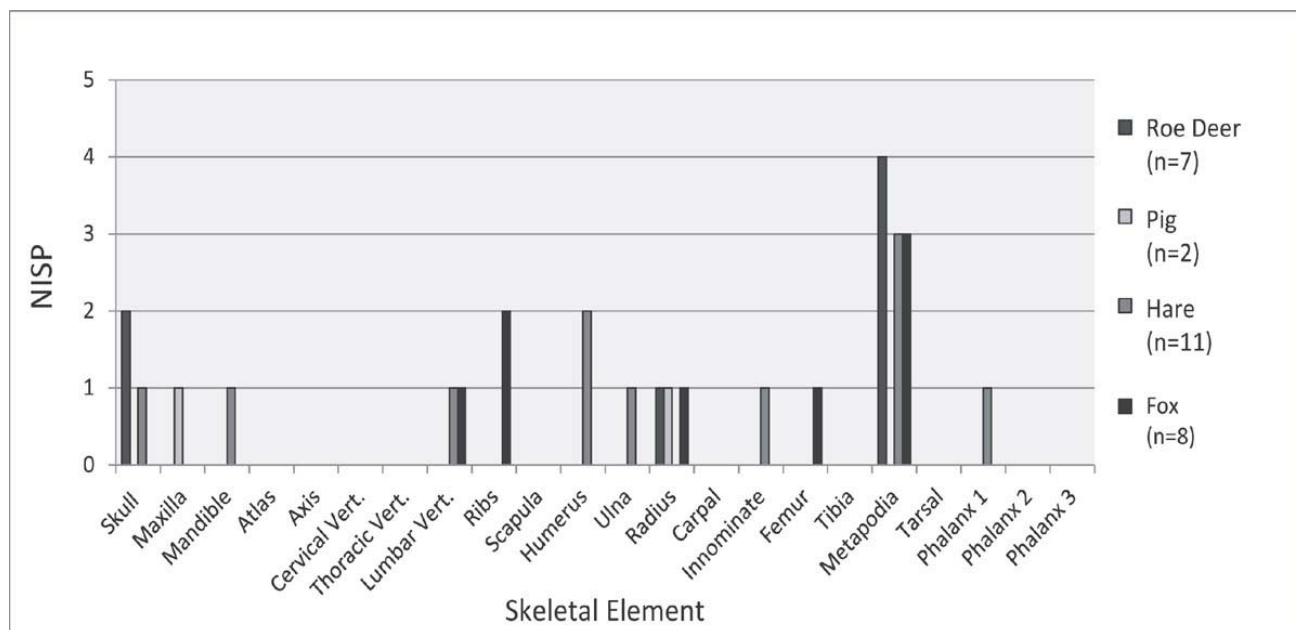


Fig. 30.5. Body part representation (excluding teeth) of wild fauna in the Neolithic at Vela Špilja Lošinj.

Discussion and conclusions

Though it is important to consider the Mesolithic-Neolithic transition as a process rather than a dichotomy in the Adriatic and the Balkans writ large (Voytek 2011), there does seem to be a substantial gap between the two at the site of VSL and indeed at many sites along the coastline (Forenbaher *et al.* 2013), Domestic sheep and goat must have been imported to the island of Lošinj, and it seems that rather than local hunter-gatherers adopting these animals from neighbouring agro-pastoralists, the site was used by incoming Neolithic herders at a very early date. The fact that the cave was once inland in the Great Adriatic Plain in the upper Pleistocene, and an island by the early Holocene, would have had a substantial impact on the lifestyle of the cave's inhabitants and particularly on the availability of food species consumed. The utilisation of the large variety of game available during the Mesolithic may not have been possible by the time the island was completely cut off from the mainland at the start of the Neolithic. A collapse of this 'broad-spectrum' diet may have followed the local extirpation of native red deer and decrease in other wild species on the island in the early Holocene, driving the foragers who used this cave either to use lowland coastal sites with easy access to marine resources, or to move further inland away from the receding coastline. Use of the cave appears to have been abandoned at the end of the Mesolithic, and resumed by a new population of pastoralists in the Neolithic.

Acknowledgements

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Using faunal remains to evaluate social stratification in the Middle Iron Age: the fortified village of Mas Castellar de Pontós, north-east Iberian Peninsula

Lídia Colominas

Introduction

Spatial analysis of Middle Iron Age settlements in the north-eastern Iberian Peninsula has documented a series of *oppida*, each with a dependent territory and subordinate sites (Asensio *et al.* 2001; Sanmartí 2004; Burch *et al.* 2010; Nolla *et al.* 2010). Additionally, variability in domestic architecture has been interpreted as the result of a hierarchy of domestic spaces within a number of these settlements (Belarte 2008; Belarte *et al.* 2009). This hierarchisation between and within settlements, together with possibly restricted access to funerary ritual, has been used to characterise the communities established in the northeast Iberian Peninsula between the fifth and second centuries BC as complex and stratified (Ruiz 1998; Asensio *et al.* 2001; Sanmartí 2004; Gracia 2005; Grau 2007; Bonet *et al.* 2008). These formulations, however, rarely integrate non-architectural data, such as faunal remains.

Faunal remains, as the waste products from the processing and consumption of meat, are an important source of information on food consumption. Food creates and constitutes social relationships and may be linked to status and power (Crabtree 1990; Dietler and Hayden 2001; Pollock 2003; Dietler 2007; Twiss 2007; Porter 2011). Food and the places in which it is consumed represent powerful means and loci of social representation and of the construction and negotiation of power. Therefore, cooking is not solely a technological process that makes raw resources edible and neither is eating solely a biological process that enables survival (Lupton 1996). Through foodstuffs, their preparation and consumption, social identity is staged. Furthermore, in complex societies, the differential consumption of animals and portions thereof may serve to create status distinctions (deFrance 2009). Hence, the study of faunal remains can shed valuable light on the politics and ideology of complex societies and on the existence of social stratification.

Accordingly, this paper evaluates the possibility of social stratification at the northeast Iberian village of Mas Castellar de Pontós by analysis of a faunal assemblage thought to represent waste from the processing and consumption of foodstuffs at the site. The animals selected, the body parts consumed, the way in which these were processed and cooked, and the areas in which these remains were disposed of will be examined to explore the possible existence of social asymmetries among the

village's inhabitants in terms of access to and consumption of meat products.

The Site of Mas Castellar de Pontós

Mas Castellar de Pontós is a 2000 sq m fortified village, occupied from the mid-fifth to the mid-fourth century BC (Fig. 31.1) and associated with a 2.5 ha area of storage pits (Pons 2002). The site was chosen for this study because it not only presents a relatively complex and monumental defensive system, but also shows architectural differences between its constituent households. Excavations revealed the presence of a defensive system composed of a wall reinforced by a tower and a lateral bastion and two moats. Attached to the wall, four contemporary houses were documented, each with two or three rooms each and a surface area of 40–45 sq m (Fig. 31.1). The architecture and contents of the four houses suggest that these were domestic units used for habitation and activities relating to the storage and consumption of food products (Pons 2002). One of the houses (household 5), however, is comprised of rectangular rooms set around an open-air paved patio, a layout described as 'Mediterranean' and considered of Greek influence (Pons 2002). The combination of monumental defensive constructions and of marked architectural differences between the houses so enclosed led scholars to consider the existence of different social classes within the village (Asensio and Pons 2004–2005).

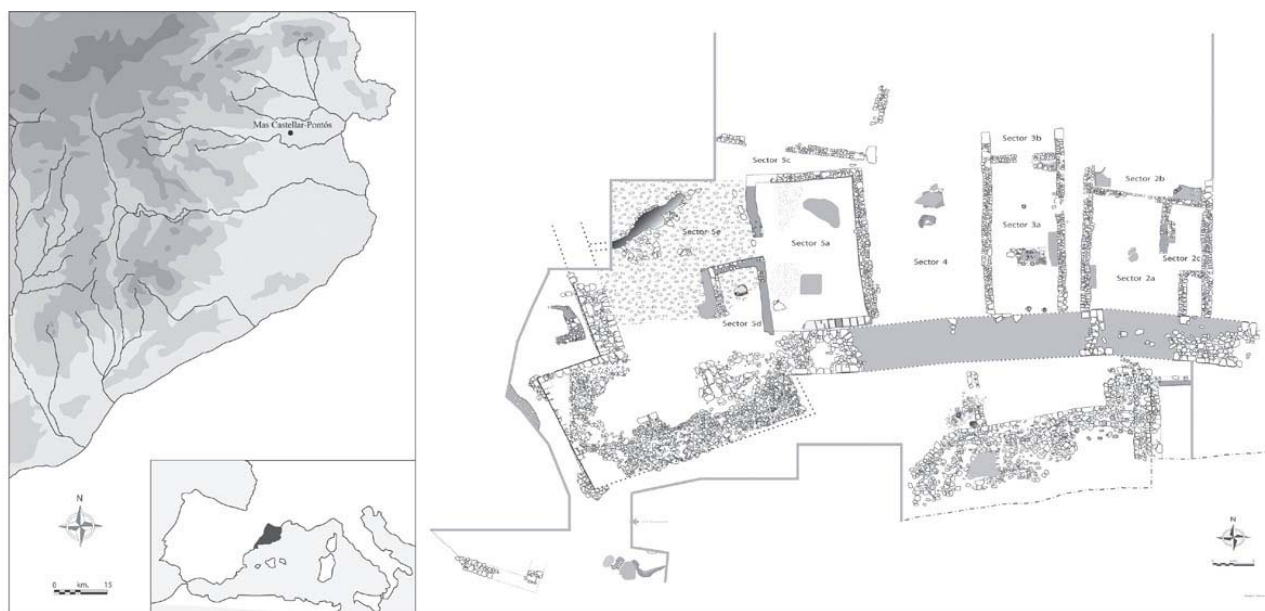


Fig. 31.1. Location and plan of Mas Castellar de Pontós (after Pons 2002).

Spatial patterning of faunal remains at Mas Castellar de Pontós

The use of animal remains to determine social status requires prior consideration of various taphonomic processes and contextual issues related to deposition and site formation, as a large number of specific formation processes and a much larger number of potential process combinations can contribute to the genesis of any deposit (Schiffer 1983). For the present study, therefore, only faunal assemblages recovered from stratigraphic units located inside the households and associated with their occupation floors were chosen. Bone accumulations from known rubbish disposal areas have been omitted from the present study, as has material recovered inside the domestic units, but from stratigraphic units

linked to their construction and/or abandonment. A total of 952 hand-collected faunal remains from the four households have been analysed (Table 31.1). The following study of these remains will centre around a detailed analysis of taxonomic distinctions, age profiles, body-part frequencies, and butchering patterns, as well as evidence of cooking methods.

Frequency of taxa

In domestic units 2, 3 and 4, sheep and goat remains are the most abundant followed by those of pig and cattle (Table 31.1). In household 5, on the other hand, cattle remains are most abundant (Table 31.1). Taxonomic diversity also differs between domestic units: households 2 and 3 only contain remains of sheep, goat, pig and cattle, whereas household 4 also has those of rabbit and red deer, and household 5 is the most taxonomically variable, with specimens of horse, fox, hare and rabbit in addition to the common domesticates.

Kill-off patterns

The study of kill-off patterns was based on analysis of the epiphyseal fusion of limb bones (Barone 1976), as too few mandibles were recovered from the various households for a reliable assessment on the basis of dental data. For sheep/goats, fused specimens, mainly of body parts that fuse prior to 42 months, predominate in all four domestic units (Table 31.2), indicating a consistent prevalence of sub-adult and adult remains. For pigs, fused and unfused specimens, again mainly from body parts fusing prior to 42 months, are present in very similar numbers, indicating a predominance of sub-adult pigs in all four domestic units. A different pattern is observed for cattle: with one exception, all specimens, including several of body parts that fuse after 4 years of age, are fused in all domestic units, indicating the slaughter of most cattle as adults.

Body part representation

Body-part representation is similar for the four domestic units (Fig. 31.2). In each case, all portions of the skeleton are present, with the meat-rich upper limbs better represented than the feet. The representation of cranial specimens is most variable between the four domestic units, while the particularly high frequency of trunk and low frequency of foot specimens in household 5 is noteworthy.

Table 31.1. Absolute and relative abundances of mammal remains from the four households at Mas Castellar de Pontós

<i>Taxon</i>	<i>Household 2</i>		<i>Household 3</i>		<i>Household 4</i>		<i>Household 5</i>		<i>Total</i>
	<i>NISP</i>	<i>%</i>	<i>NISP</i>	<i>%</i>	<i>NISP</i>	<i>%</i>	<i>NISP</i>	<i>%</i>	
Sheep/goat	28	51.9	105	53.3	84	48.3	52	28.1	269
Pig	15	27.8	64	32.5	44	25.3	45	24.3	168
Cattle	11	20.4	28	14.2	43	24.7	76	41.1	158
Horse	0	0.0	0	0.0	0	0.0	2	1.1	2
Red deer	0	0.0	0	0.0	1	0.6	0	0.0	1
Hare	0	0.0	0	0.0	0	0.0	3	1.6	3
Rabbit	0	0.0	0	0.0	2	1.2	2	1.1	4
Fox	0	0.0	0	0.0	0	0.0	5	2.7	5
NISP	54	52.4	197	59.7	174	68.5	185	69.9	610
Non-identifiable	49	47.6	133	40.3	75	31.5	85	30.1	342
Total	103	100	330	100	249	100	270	100	952

key: NISP = number of identified specimens

Table 31.2. Frequencies of unfused and fused bones of sheep/goats, pigs and cattle from the four households at Mas Castellar de Pontós

<i>Elements</i>	<i>Household 2</i>		<i>Household 3</i>		<i>Household 4</i>		<i>Household 5</i>		<i>Age at fusion</i>
	<i>Unfused</i>	<i>Fused</i>	<i>Unfused</i>	<i>Fused</i>	<i>Unfused</i>	<i>Fused</i>	<i>Unfused</i>	<i>Fused</i>	
<i>Sheep/Goat</i>									
Humerus, d		1	1	3		2	1	1	3–4 months
Radius, p						3			3–4 months
Phalanx I	2	1				2	1	4	7–10 months
Tibia, d				2		3		1	15–20 months
Metapodial, d		2		1	1	3		1	20–24 months
Femur, p		1				1	1		36–42 months
Humerus, p				2					42 months
Radius, d		1		1					42 months
Ulna, p									42 months
Femur, d									42 months
Tibia, p		1		1		1			42 months
<i>Pig</i>	<i>Unfused</i>	<i>Fused</i>	<i>Unfused</i>	<i>Fused</i>	<i>Unfused</i>	<i>Fused</i>	<i>Unfused</i>	<i>Fused</i>	<i>Age at fusion</i>
Humerus, d									12 months
Radius, p			1	2		1			12 months
Phalanx I	1					3		1	12 months
Tibia, d		1				1	1		24 months
Metapodial, d	1		1	1	3	2			24 months
Ulna, p			2						36–42 months
Femur, p	1		1				1		36–42 months
Humerus, p				2					42 months
Radius, d					1			1	42 months
Femur, d									42 months
Tibia, p			1				1		42 months
<i>Cattle</i>	<i>Unfused</i>	<i>Fused</i>	<i>Unfused</i>	<i>Fused</i>	<i>Unfused</i>	<i>Fused</i>	<i>Unfused</i>	<i>Fused</i>	<i>Age at fusion</i>
Radius, p		1		1		1		2	12–15 months
Humerus, d								1	15–20 months
Phalanx I		1				2		2	20–24 months
Tibia, d						1		3	24–30 months
Metapodial, d		1						1	24–30 months
Femur, p				1			1		36–42 months
Humerus, p						1			42–48 months
Radius, d								1	42–48 months
Ulna, p						1			42–48 months
Femur, d		1		2				1	42–48 months
Tibia, p						1		3	42–48 months

key: d distal; p proximal

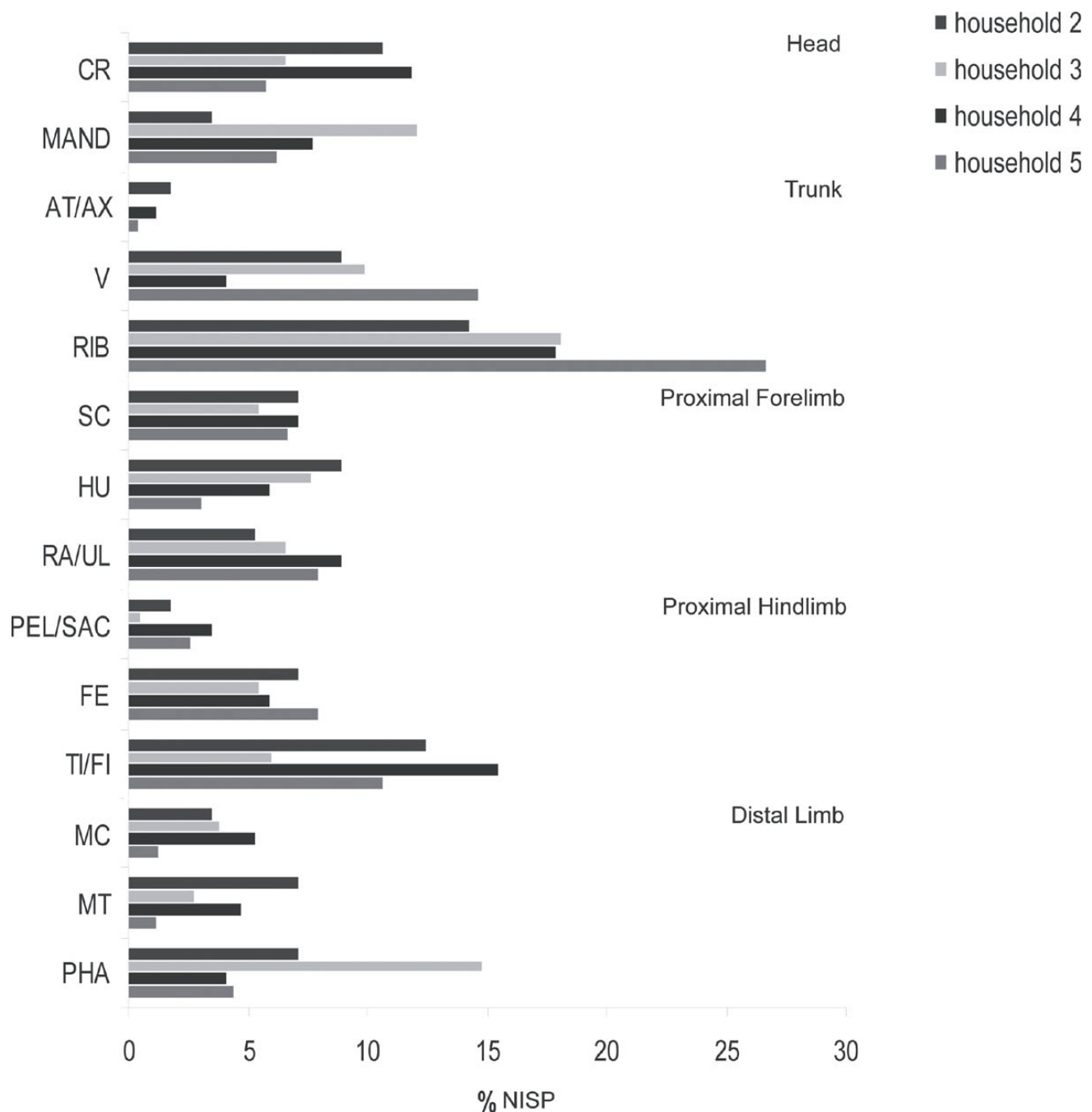


Fig. 31.2. Distribution of body parts in the four households at Mas Castellar de Pontós. Key: CR cranium; MAND mandible; AT/AX atlas/axis; V vertebra; RIB rib; Sc scapula; HU humerus; RA/UL radius/ulna; PEL/SAC pelvis/sacrum; FE femur; TI/FI tibia/fibula; MC metacarpal; MT metatarsal; PHA phalanx)

Butchery, fragmentation and burning

Butchery marks, fracture patterns and evidence of burning may yield information about the processing of animals and their preparation for human consumption, but these activities do not always leave such traces. In the assemblage under study, only 7.5% of the 610 identified specimens (NISP) exhibit butchery marks, the distribution of which by taxon and household is presented in Table 31.3.

Table 31.3. Distribution of butchered and burnt bones of sheep/goat, pig and cattle from the four households at Mas Castellar de Pontós

Taxon	Household 2			Household 3			Household 4			Household 5		
	Cut	Chop	Burnt	Cut	Chop	Burnt	Cut	Chop	Burnt	Cut	Chop	Burnt
Sheep/goat	1	2	14	1	1	50	1	2	13	3	1	2
Pig	1	–	3	1	1	12	–	1	7	2	2	1
Cattle	1	2	1	3	5	1	2	3	3	9	1	2
Total	3	4	18	5	7	67	3	6	23	14	4	5

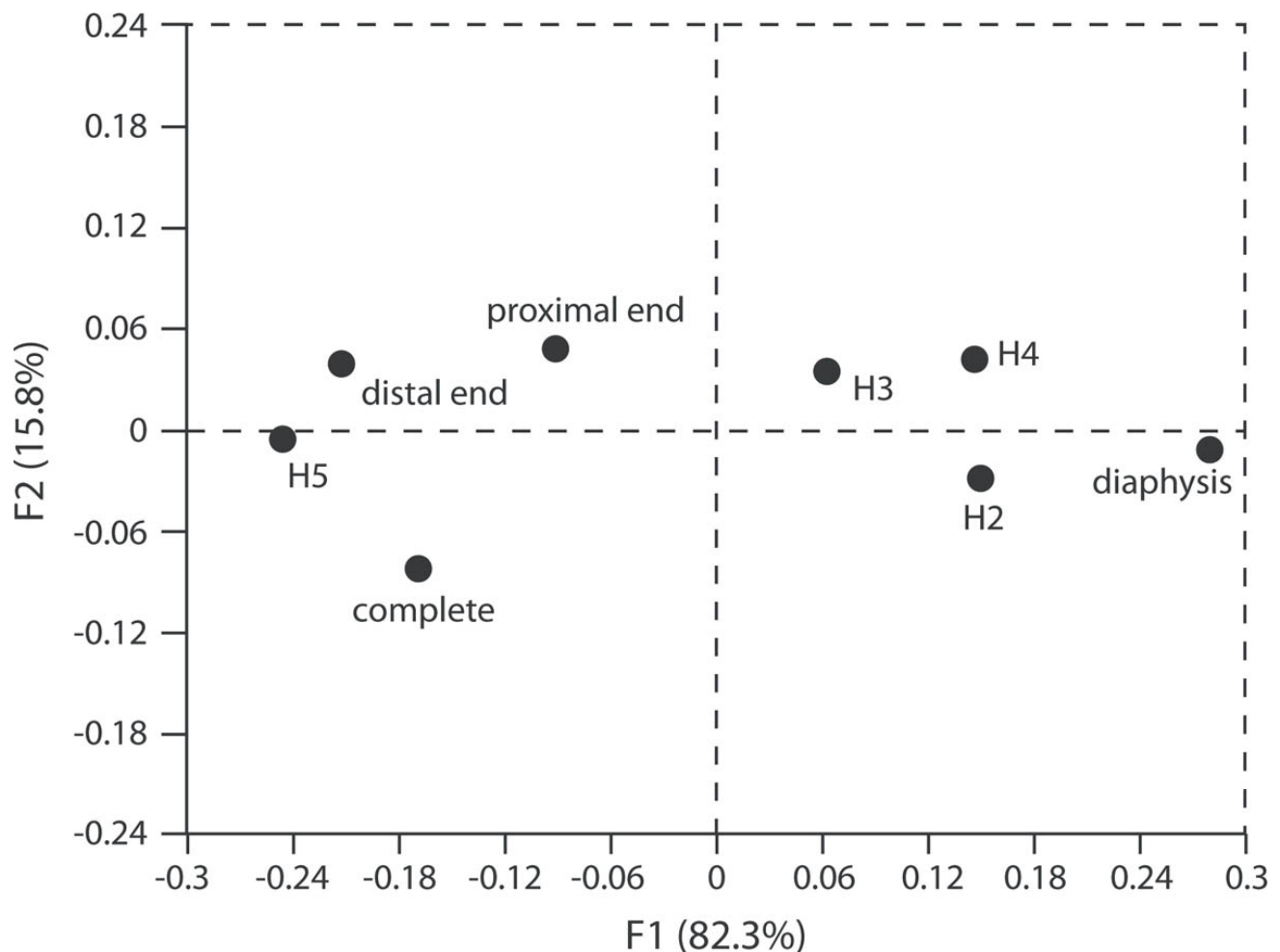


Fig. 31.3. Plot of the Correspondence Analysis (CA) of long bone fragmentation patterns by household at Mas Castellar de Pontós. Key: H2 household 2; H3 household 3; H4 household 4; H5 household 5.

The butchery evidence has been subdivided into cut and chop marks, as these may be linked to different stages in the butchery process (Lyman 1987; Gifford-Gonzalez 1989; Greenfield 2000). The former typically result from the stripping of meat from the bone during filleting or the separation of joints during dismembering, and also from skinning, whereas chop marks may be inflicted during dismembering. Chop and cut marks were documented on bones of the three major taxa represented and both were more frequent on cattle than on pig or sheep/goat bones (Table 31.3). While specimens with chop marks are more common in domestic units 2, 3 and 4, however, specimens with cut marks predominate in domestic unit 5.

Chop marks may also arise during the fracturing of bones to obtain marrow, however, and so the analysis of fracture patterns may shed light on possible marrow-extraction practices at the site. In all four households, a significant number of cattle, sheep/goat and pig bones was recorded with spiral

fractures, mostly on long bone diaphyses, such as are generally associated with the smashing of fresh bones for marrow extraction and grease rendering (Binford 1981; Rixson 1988; Church and Lyman 2003). In order to visualize the degree of fragmentation for each household and to assess any differences between them, a Correspondence Analysis (CA) was undertaken. CA allows the use of small assemblages, but was chosen primarily for its ability simultaneously to analyse different assemblages and variables (in this case, households and bone fragment types, respectively) and so to reveal relationships that would otherwise not be detected in a series of pairwise comparisons of variables (Clouse 1999; Smith and Munro 2009). In terms of fragment types, a distinction was made between complete bones, distal epiphysis/diaphysis, proximal epiphysis/diaphysis and diaphysis fragments. The first correspondence axis, plotted horizontally in Figure 31.3 and accounting for an overwhelming 82.3% of the total variation in fragmentation data, contrasts household 5, correlated with the variables 'complete', 'distal end' and also 'proximal end' on the left, with the other households and the variable 'diaphysis' on the right. The animal carcasses recovered from household 5 were less intensively processed than those from the other domestic units.

Traces of burning may also shed light on preparation of meat for consumption, but thermal alterations produced in cooking must be distinguished from those due to other activities, such as the use of bones as fuel or the intentional burning of refuse. To this end, the colour of burning traces may be informative, as the intensity of thermal alteration varies depending on the source of heat, the duration of exposure to this source, and the maximum temperature reached (Outram *et al.* 2005). Of 109 thermally altered specimens, only 13% were calcined (grey and/or white colour) and 32% burnt (black), while 55% were lightly affected (brownish). The low frequency of calcined remains suggests that intentional burning of bones, as fuel or in refuse disposal, was not the main cause of thermal alteration. The distribution of thermal alterations by taxon and household is outlined in Table 31.3, showing that burning (mainly of sheep/goat bones) is far less common in household 5 (2.2% of identified specimens) than in households 2 (20.3%), 3 (32%) and 4 (13.2%).

Spatial patterning of faunal remains in household 5

The faunal assemblage from household 5 is evidently distinctive in terms of taxonomic and body-part composition and of processing history. To what extent does the composition of this assemblage also differ between the constituent parts of household 5 (Fig. 31.1)? Of the 270 specimens recovered from this unit, 79% came from the floor of the patio (area 5e) and the remaining 21% from the floor of the main room (area 5a), while no faunal remains were found in the entrance (area 5c) or small room (area 5d).

In the main room (5a), there is a predominance of sheep/goat remains (56.1%), followed by pig (22%) and cattle (19.5%), whereas, in the patio area (5e), cattle remains are best represented (47.2%), followed by those of pigs (25%) and sheep/goats (20.1%). The patio also has the greatest taxonomic variability, with the presence of horse (1.4%), fox (2.1%) and hare (1.4%), species absent from area 5a. Rabbit is present equally in both areas (2.7% in the patio and 2.4% in area 5a). No differences in kill-off patterns have been documented, with adult cattle and sub-adult sheep/goats predominant and juvenile, sub-adult and adult pigs represented in both areas. Likewise, in terms of body-part representation, the upper limb bones are most abundant (39.8% in 5a and 43.9% in 5e) and foot bones scarce (9.4% in 5a and 7.9% in 5e) in both areas, but bones of the trunk are rather better represented in the patio (30.2%) than in the main room (20.4%). In terms of carcass processing, specimens with cut marks have been documented in both spaces, but chop marks and traces of thermal alteration only in area 5a, while 82% of the complete elements recorded for household 5 and only 11% of the diaphysis

fragments were recovered from the patio (area 5e). Thus it is the patio 5e that largely accounts for the distinctiveness of the household 5 faunal assemblage, in terms of taxonomic and body-part composition and evidence for carcass processing and cooking activities.

Communal meals and social stratification

Meat consumption in the various households that made up the settlement of Mas Castellar de Pontós was focussed on the common domestic animals – sheep, goats, pigs and cattle. In households 2, 3 and 4, however, sheep/goats predominate, followed by pigs, whereas in household 5 cattle are best represented. Household 5 also has the greatest taxonomic diversity, including horse, fox, hare and rabbit. Within household 5, both the predominance of cattle and the high taxon diversity largely reflect the composition of the sub-assemblage from the patio (area 5e). In terms of age at slaughter, the animals represented in all four domestic units were mostly sub-adults and adults together with a few infants and juveniles. Body-part representation shows a predominance of meat-rich upper limb bones in all four households.

Among the bones from the patio (area 5e) of household 5, however, trunk elements are also well represented and there are fewer traces of burning, fewer chop marks and less fragmentation than in the material from other households. Carcass parts consumed and discarded in patio 5e were thus cooked differently to those consumed and discarded elsewhere. In domestic units 2–4, long bones were systematically broken to extract the marrow fat (Rixson 1988; Crader 1990; Lupo and Schmitt 1997; Church and Lyman 2003); boiling in pots to create nutritious broths would be consistent with the observed heavy fragmentation, while traces of burning may reflect heating of bones to facilitate breakage. Conversely, in the patio (area 5e), the scarce breakage of long bones and rarity of burning traces show that meat products discarded here were prepared differently, perhaps by roasting as this does not require fragmentation of the bones and may not have left traces of burning, because most of the bones would have been protected from fire by the muscles that surrounded them.

Ethnoarchaeological and ethnographic studies have shown that feasts may be marked by unusual foods and/or methods of preparation and discard, by the temporal or spatial framing of the event, by the material culture used or by associated performances (Twiss 2008). Meat is frequently the predominant food at feasts, and large animals in particular are common culinary centrepieces at these events (de Garine 1996; Clarke 2001; Junker 2001; Hayden 2003). Such studies have highlighted the important role played by cattle in commensal festivities, whether because of their high meat content or because of their association with wealth and/or the investment they entail (Russell 1998; Hayden 2001; Aranda *et al.* 2007). Communal consumption of meat may be used to establish relationships between individuals, domestic units, lineages or communities. These relationships can be of reciprocity or alliance, whether political or economic, or even of social cohesion, but they can also be used to create and/or maintain various forms of social asymmetry (Hayden 1996; 2001; Dietler 2001; Dietler and Hayden 2001; Wiessner 2001; Spielmann 2002; Bray 2003; Adams 2004).

At Mas Castellar de Pontós, detailed study of the spatial distribution of faunal remains interpreted in the light of ethnoarchaeological studies suggests communal consumption took place in the patio of household 5. Whether this practice translated into some form of social inequality between the members of the community is difficult to establish. On the one hand, the association of the refuse from this commensality with a particular household may mean that the rituals conducted there effectively distinguished this domestic unit, and its residents, from the rest of the community. If only certain members of the community could participate in such commensality, it may have served to create or maintain social asymmetries, perhaps social stratification, within the settlement. On the other

hand, given the similarity between the faunal remains from the main room (5a) of household 5 and those from the other three households, the patio (5e) of household 5 could be interpreted as a communal space for the village, involving all members of the community in rituals that promoted social cohesion.

Conclusions

The data presented here have documented that meat, primarily of sheep/goats and to a lesser extent of pigs and cattle, was consumed in each of the four households excavated to date within the fortified settlement of Mas Castellar de Pontós. After the removal of meat, the bones were broken open to obtain grease and marrow. The consumption of animals, in terms of both taxon and age at slaughter, and the sequence of carcass processing were very similar in households 2–4 and in the main room of household 5, suggesting that any social asymmetries between the residents of these domestic units were not reflected in the ‘everyday’ consumption of meat. Detailed spatial analysis, however, has revealed that communal meals took place in the patio of household 5 and that the food consumed there and its method of preparation differed significantly from those documented in an everyday context.

This paper has thus successfully shown that the analysis of faunal remains may shed light on status and inter-household relationships, as these are reflected in food consumption.

The faunal data from Mas Castellar de Pontós have shown consistent evidence of social complexity within that community, but do not demonstrate social stratification in the sense of unequal access to the distribution and consumption of meat products. This study highlights the need for integrated interdisciplinary analysis of all available components of the archaeological record as the basis for successful investigation of complex past social realities.

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The economy of medieval and post-medieval Vyborg, Russia, in its historical context

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Introduction

The modern Russian city of Vyborg is situated 150 km north-west of Petersburg, in immediate proximity to the Russian-Finnish frontier. The history of this settlement goes back to medieval times. The first Swedish stronghold was constructed here at the very end of the thirteenth century. In the fifteenth century, Vyborg gained city status and became the largest trading and political centre in the Karelian isthmus and the modern Petersburg region. The city was surrounded by a defensive wall. In the second half of the sixteenth century, the German population dominated the city, introducing their domestic customs to the life of the townspeople. Vyborg quickly grew, and its territory almost doubled in size. In the middle of seventeenth century the city survived a devastating fire after which it was rebuilt practically from zero. The city was captured by Russian armies in 1710 and subsequently became part of the Russian empire (Volkova *et al.* 2005).

Research into the medieval archaeological layers of Vyborg city were undertaken for the first time in 2004. Bone materials were most numerous from the 2011 and 2012 seasons, the excavations by Dr A. I. Saksa. This paper is devoted to the examination of these bones. Chronologically these layers extend from the first quarter of the fifteenth century up to the beginning of the eighteenth century. For practically all this period the city was under the authority of the Swedish crown. The bone material provides a rare opportunity to reconstruct the nature of the economy of this late- and post-medieval Scandinavian city.

The excavated area is about 250 m². It mainly covers one of the city streets and an adjoining courtyard, which was probably for publicly accessible. The stratigraphic sequence makes it possible to divide the bone assemblage into seven periods:

1. c. 1680–1710
2. c. 1660–1680
3. c. 1640–1660
4. c. 1580–1640
5. c. 1540–1580

6. c. 1500–1540
7. c. 1430–1500

During this time this territory was a part of the Swedish state and Vyborg can be regarded as a Swedish city.

About 10,400 bone fragments have been identified in total. The details of the faunal remains are shown in Table 32.1. In general it corresponds to the situation in some other Swedish urban settlements (Tourunen 2003; Macheridis and Totnberg 2005). The percentages of the main animal groups are shown in Figure 32.1. This diagram shows that during the first period of the settlement the main component of the meat diet was cow, comprising 63% of all the identified bones. This gradually reduces, and the proportion of caprines grows, so that by the middle of the seventeenth century these two categories of domestic animals were present in almost equal frequencies. This was the period in which the city survived one of the most terrible fires in its history. This catastrophic event had an impact on the city's stock-raising economy. It is possible to assume that a lot of cattle was lost in this fire. Furthermore, the general economic decline after this major destruction compelled the inhabitants to move to poorer quality and more accessible meat, namely mutton and even goat. Caprines were a more important source of food in the middle of the seventeenth century. This is indirectly supported by the fact that precisely during this period the proportion of young animals (providing the tenderest, best quality meat) is at its highest, comprising almost 30% of all caprine remains, whereas during other periods it amounts only to 18–20%.

Table 32.1. The details of the faunal remains from Vyborg by period (No. bones/No. individuals)

Taxon	1		2		3		4		5		6		7	
	Bones/ indiv.	%	Bones/ indiv.	%	Bones/ indiv.	%	Bones/ indiv.	%	Bones/ indiv.	%	Bones/ indiv.	%	Bones/ indiv.	%
Squirrel <i>Sciurus vulgaris</i> L.											1/1	0.1		
Mountain hare <i>Lepus timidus</i> L.	113/7	5.2	7/1	0.9	20/4	1.2	46/9	1.7	16/3	1.2	7/3	0.6	2/	0.6
Beaver <i>Castor fiber</i> L.									1/1	0.1				
Cat <i>Felis domestica</i> L.	5/2	0.2	1/1	0.1			2/1	0.1	3/1	0.2	3/1	0.2	1/1	0.3
Brown bear <i>Ursus arctos</i> L.	1/1	0.1												
Horse <i>Equus caballus</i> L.			2/1	0.2							2/1	0.2		
Cow <i>Bos taurus</i> L.	990/25	45.2	391/16	47.5	751/23	43.5	1258/34	46.5	755/23	55.9	791/26	62.2	204/7	63.9
Goat <i>Capra hircus</i> L.	141/16	6.4	52/7	6.3	111/17	6.4	116/14	4.3	49/8	3.6	28/4	2.2	10/2	3.1
Sheep <i>Ovis aries</i> L.	119/23	5.4	37/8	4.5	128/21	7.4	229/45	8.5	79/12	5.8	76/16	6.0	33/9	10.3
Sheep or Goat <i>Ovis et Capra</i>	482/16	22.0	222/13	27.0	481/24	27.9	630/35	23.3	277/14	20.5	188/13	14.8	31/4	9.7
Dog <i>Canis familiaris</i> L.					2/1	0.1	4	0.1			6/1	0.5	3/1	0.9
Pig <i>Sus scrofa dom. L.</i>	156/11	7.1	86/9	10.4	172/13	10.0	301/18	11.1	149/15	11.0	142/11	11.2	31/3	9.7
Ringed seal <i>Pusa hispida</i> Scireb.			1/1	0.1	1/1	0.1	1/1	0.1						
Birds <i>Aves</i> sp.	112	5.1	12	1.5	25	1.4	38	1.4	19	1.4	11	0.9	1	0.3
Fishes <i>Pices</i>	72	3.3	12	1.5	35	2.0	80	3.0	3	0.2	17	1.3	3	0.9
Total identified	2191	100	823	100	1726	100	2705	100	1351	100	1272	100	319	100

After the middle of the seventeenth century the percentage of caprines decreases somewhat, and the proportion of cows increases although not to the earlier level. And at the beginning of the eighteenth century the proportion of all the domestic animals decreases, while that of fish, birds (including wild birds), and other species, mainly hare, increases slightly. Indirectly this suggests that there was a drop in the standard of living of the townspeople, caused by the unstable political situation during this period.

Sheep and goats

The percentage of sheep and goats was not always identical. In the earliest horizons, in the fifteenth and first half of sixteenth centuries, goats amounted to approximately 23–26% of the number of sheep. Later, in the second half of the sixteenth century and the first half of seventeenth century, goats became a bit more numerous: about 33–38%. In the middle of the seventeenth century, goats comprised 46% of fragments. In second half of the seventeenth century they increase to 58%, and in the uppermost layers, the end of the seventeenth and beginning of eighteenth centuries, goats make up an average of 54% of all domestic caprines identified to species in Vyborg.

Goats were probably kept mainly for their hair, and sheep probably for meat, during the last periods of Vyborg as a Swedish fortress. Keeping goats for hair probably brought in quite a good income. Caprine-rearing strategies change through time, as the proportion of young animals decreases somewhat during the second half of the seventeenth century but then increases again at the beginning of the eighteenth century. Huge quantities of goat horn cores are present, particularly those of adult large males (Fig. 32.2). In level 3, the mid-seventeenth century, when the remains of caprines were most common, horns amounted to only about 11% of remains of goats. However, by the beginning of the eighteenth century this had increased to 33.3%. The keeping of so many males into maturity and even old age can only result from the production of high-quality hair in commercial quantities. It is well known that the quality of a fleece improves with age, but the quality of the meat does not.

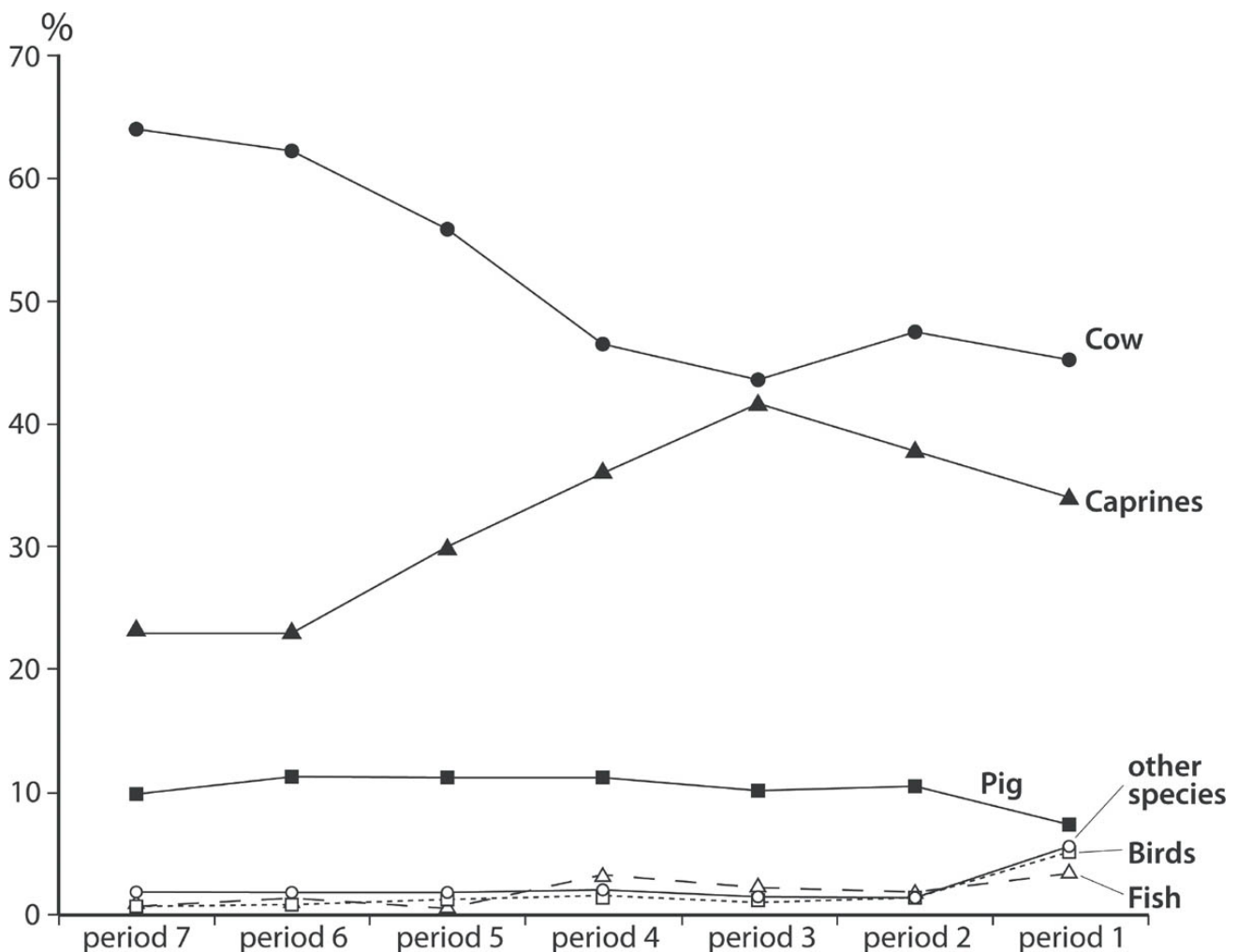


Fig. 32.1. Percentages of the main groups of animals in the different periods at Vyborg.



Fig. 32.2. Large fragments of skulls of domestic goats from the upper cultural horizons of old Vyborg.

Table 32.2. Measurements of sheep metacarpals from old Vyborg and of modern primitive breeds

	VYBORG (n = 42)		Some archaic breeds of sheep (from Tsalkin, 1961)					
	range	mean	Chuntuk (n = 6)		Romanovskaia (n = 31)		Tzigaia (n = 11)	
			range	mean	range	mean	range	mean
1*	105.2–125.6	115.1	145.0–170.5	155.2	123.2–142.0	131.8	118.0–136.0	128.0
2	16.6–22.7	20.5	24.8–27.2	25.8	22.5–27.3	24.7	23.3–26.3	25.0
3	9.6–13.3	11.6	12.8–15.0	13.7	12.5–15.4	14.0	11.6–15.3	14.3
4	19.9–23.9	22.7	27.2–30.2	29.0	23.7–28.0	26.0	25.3–27.5	26.5

* The measurements are: 1 – greatest length (GL); 2 – proximal breadth (Bp); 3 – diaphysiseal breadth (SD); 4 – distal breadth (Bd).

Insights about the sizes and breeds of sheep and goats kept by the inhabitants of old Vyborg can be gained from the sizes and proportions of their metacarpals, which were present in large quantities. These data are presented in Table 32.2. Metacarpals are considered the most indicative elements in practical zooarchaeology. In contrast to skulls, they are found frequently undamaged and, more important, have more characteristic features peculiar to a particular morphological group than the metatarsals. Metacarpal measurements of domestic sheep of primitive breeds are also presented in Table 32.2. The corresponding data for sheep from some late medieval sites in northern Russia are presented in Table 32.3 (from Tsalkin 1954; 1956).

The Chuntuk breed is the most ancient of them all. They have practically disappeared in recent times. There are brief comments in older descriptions (Ivanov 1940) but even at that time this ancient breed had almost completely disappeared. They were known as fat-tailed sheep in the Ukraine and in

Crimea, and most likely came from the Central Asian steppes, as they are very similar in appearance to Kalmyk sheep and the sheep of Central Asia in general.

Table 32.3. Metacarpal measurements of sheep from some medieval sites in the northern Russian plain (from Tsalkin 1954; 1956)

	<i>Novgorod (n = 11)</i>		<i>Pskov (n = 9)</i>		<i>Old Ladoga (n = 18)</i>		<i>Grodno (n = 5)</i>	
	<i>range</i>	<i>mean</i>	<i>range</i>	<i>mean</i>	<i>range</i>	<i>mean</i>	<i>range</i>	<i>mean</i>
1	110.0–128.0	118.2	118.0–131.0	124.4	115.0–135.0	126.4	114.0–131.0	125.0
2	19.0–22.0	20.6	20.5–23.7	21.8	20.5–24.0	21.9	21.0–24.0	22.8
3	11.1–13.6	12.3	12.5–14.8	13.2	11.3–15.0	13.0	11.6–15.5	13.7
4	21.4–24.0	22.7	23.0–24.7	24.0	22.0–26.5	24.3	22.0–26.5	24.7

See Table 32.2 for the measurement definitions

Tzigaia sheep also have very ancient origins. One agricultural reference book describes this breed as follows: ‘... It is one of the most ancient breeds in the world. According to M. F. Ivanov, tzigaia sheep descend from fine-fleeced sheep, which bred on the pastures of Asia Minor, and they were known 800 years prior to the common era’ (Semenov and Sel’kin 1994, 175). This breed came to Europe in historical times from the Balkan peninsula, where it was a native breed from ancient times.

Romanovskaia sheep have become more popular in the last 200 years. This is a little later in time than the date of our assemblages. It is commonly believed that it was bred from local forms of Eastern Europe short-tailed sheep, which were present in the European part of the former USSR almost since the Bronze Age (Ivanov 1940).

For each sample in Tables 32.2 and 32.3, the ratio of the width of the diaphysis and of the proximal and distal epiphyses to the overall length of the bone has been calculated. Thus three indices of proportion have been calculated for each type. Comparison between the breeds has been carried out by simple cluster analysis. The result is presented in Figure 32.3. The analysis was carried out by means of the program *PAST*, which was created specifically for application to palaeontological materials (Hammer *et al.* 2001).

It is clear from the cladogram (Fig. 32.3) that the samples form two different groups. One group consists of the medieval sheep from the sites of the North Russian plain (Novgorod, Pskov, Old Ladoga and Grodno). The sheep from the first three appear almost identical. The sheep from Grodno differ a little, but are nevertheless much closer to this morphological group on the proportions of its metacarpals. The second group unites the modern primitive breeds of Romanovskaia and Tzigaia. The sheep of old Vyborg belong to same group, being most similar to the eastern European Romanovskaia breed. The Tzigaia sheep of Balkan origin appears less similar to these northern forms. The Central Asian Chuntuk breed, as expected, differs strongly from all these northern forms and is an outlier in the diagram.

These aspects of the morphology of the sheep of old Vyborg can be explained by the fact they, compared to the earlier medieval sheep of Novgorod, Pskov and Old Ladoga, are probably already a product of some selection activity. Apparently, sheep of this type served as the basis for the final formation of the romanovskaia breed. This process took place rather soon after the formation of the Vyborg sequence, about in the middle of the eighteenth century. The majority of the sheep metacarpals came from period 1, that is the end of the seventeenth and the beginning of the eighteenth century.

It is much more difficult to speak about a breed of goats. First of all, even at the present time

there is much more morphological uniformity among domestic goats than among sheep. Morphological criteria of breeds have been developed only for a very small number of the newest pedigree groups, mainly the producers of fine hair or dairy products. Most are however assigned to so-called local rough-haired breeds, not by reason of exterior criteria, which are poorly elaborated, but rather because of the geographical localization of the herds. Suffice it to say, that the sheep in the territory of the former USSR are grouped by livestock specialists into 55 breeds with precise external criteria that distinguish them from each other, but only nine breeds are defined for goats (Orehov 1994). Goats from the main homogeneous type are provisionally referred to one or other local group, on the basis of the area in which they occur. The timing of their appearance is not reliably known.

Metacarpals from various archaeological sites in northern Russia are therefore compared simply among themselves in Table 32.4. These include, alongside Vyborg, bones from medieval Old Ladoga and Pskov, from Novgorod (dating from the thirteenth–seventeenth centuries) and from Grodno (dating from the sixteenth and seventeenth centuries (Tsalkin 1956). The same indexes have been calculated as for sheep, and the cladogram is presented in Figure 32.4. It is clear that the goats of old Vyborg are most similar to those of late medieval Novgorod. Most likely this was a type that had been widely distributed throughout all of northern Russia since the earliest times. It is necessary to note that, as Table 32.4 indicates, the number of specimens from the other sites is very small. Only eight bones were measured by Tsalkin from Novgorod, and from the other sites he describes no more than two.

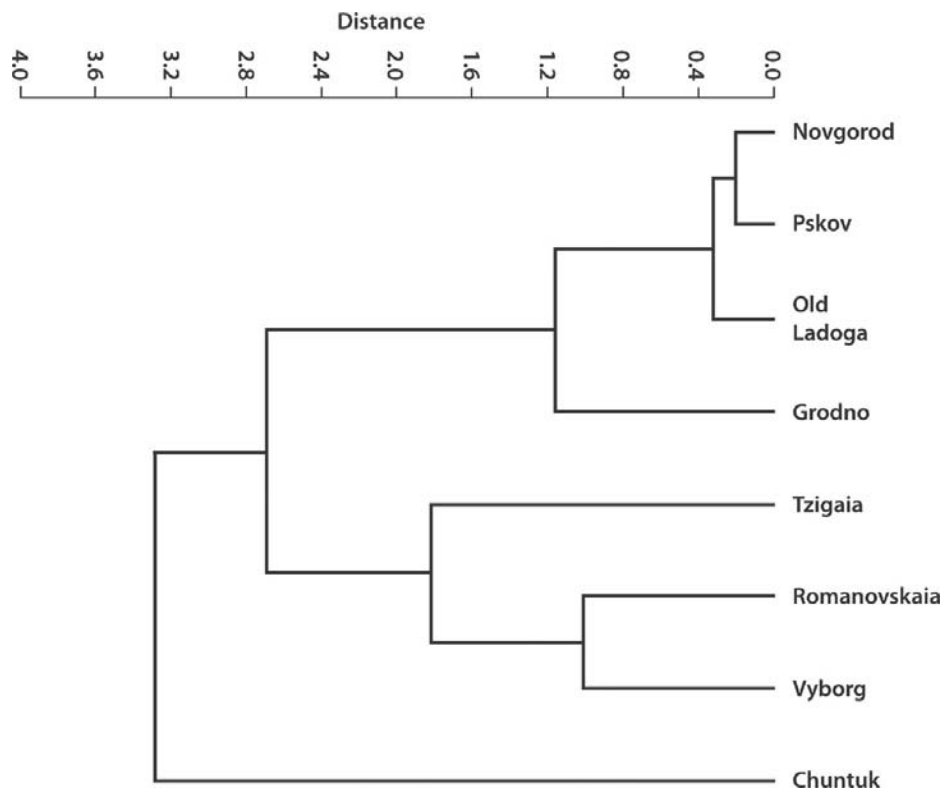


Fig. 32.3. A measure of similarity of proportions of sheep metacarpals from old Vyborg, other archaeological sites, and modern primitive breeds.

The sheep of old Vyborg are noteworthy because of their small size. Based on the average length of the metacarpal (Tsalkin 1961), the withers height of sheep was no more than 54 cm. Archaic romanovskaya sheep, proportionally similar to those from Vyborg, have an average withers height

(according to the same authority) of 65 cm.

The goats were very small too. Tsalkin (1956) states that goats from the forest belt of Russia were smaller the modern ones. The goats of Vyborg are quite small in size among the specimens available for comparison. Only one each from Grodno and Pskov are as small as the mean at Vyborg.

Caprine slaughter, examined via the stages of tooth eruption of young individuals, occurred throughout the year, but predominantly during the autumn. The general anatomical composition of the caprine assemblage is presented in Table 32.5. Fragments of skull, horns and jaws form the cranial group. The group ‘scapula, pelvis and longbones’ comprises all areas of the carcass which contain at least some meat. ‘Inedible parts of carcass’ are the limb extremities, starting from the carpus or tarsus. The table shows that the anatomic composition of the caprine assemblages was similar in all periods. There is however an appreciable increase of the meat-bearing parts of the carcass and a reduction in cranial fragments in period 3. This is the mid-seventeenth century, just when the proportion of goats and sheep reaches the maximum (see Fig. 32.1). It testifies once again that during that period caprines were exploited especially for meat. During the last period the proportion of the edible areas decreases, but ribs, vertebrae, cranial fragments and distal limbs increase a little. This is probably because we are dealing not only with food refuse, but also with the remains of animals butchered for manufacturing purposes. It is therefore possible to assume that the activities carried out on the excavated area of the city changed somewhat through time.

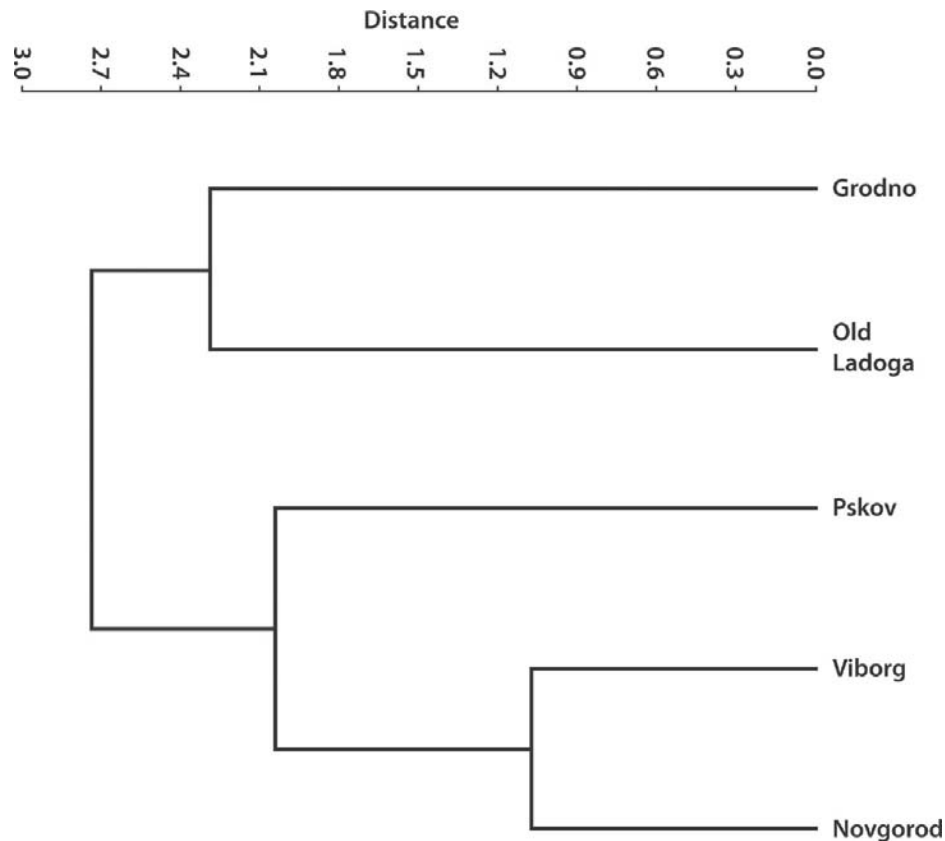


Fig. 32.4. A measure of similarity of proportions of goat metacarpals from old Vyborg and other archaeological sites.

Table 32.4. Measurements of goat metacarpals from Vyborg, and from other sites in northern Russia (from Tsalkin 1954; 1956)

	<i>VYBORG (n = 21)</i>		<i>Novgorod (n = 8)</i>		<i>Old Ladoga</i>	<i>Pskov</i>	<i>Grodno</i>		
	<i>range</i>	<i>mean</i>	<i>range</i>	<i>mean</i>		<i>mean</i>		<i>mean</i>	
1	97.8–113.8	103.4	105.0–120.0	112.1	108.0	103.0; 108.0	105.5	114.0; 103.0	108.5
2	19.5–28.8	22.7	22.5–28.0	25.3	23.0	25.2; 23.0	24.1	23.0	23.0
3	13.1–20.1	15.7	16.4–20.5	18.0	15.0	17.4; 16.7	17.1	15.0; 15.1	15.1
4	21.3–31.6	26	26.0–31.5	28.3	26.5	30.0; 27.0	28.5	26.5; 25.5	26.0

See Table 32.2 for the measurements.

Cow

The remains of cows are common in all periods of the city's existence. Their frequency falls in the middle of the seventeenth century, possibly due to the catastrophic fire, but it rises again at the beginning of the eighteenth century. The proportion of young animals increased steadily through time. From layer 7 to layer 2 (early fifteenth–late seventeenth centuries) the proportion of young animals increases from 11% to 19%. Indirectly this suggests an increasing importance for dairy products. However, in the latest period, the end of the seventeenth and the beginning of the eighteenth century, the proportion of young animals falls to its lowest value: 8%. This suggests a change in cattle rearing strategies. Besides meat and milk, cows probably provided skins or were used for draft purposes.

Table 32.5. Anatomical distribution in percentages of the bones of domestic caprines at Vyborg, subdivided by period

<i>Anatomical categories</i>	<i>Periods</i>						
	<i>7</i>	<i>6</i>	<i>5</i>	<i>4</i>	<i>3</i>	<i>2</i>	<i>1</i>
Cranial frags	35.1	24.3	18.5	24.1	12.0	20.3	23.6
Ribs & vertebrae	8.1	24.7	31.5	26.9	32.1	33.4	33.4
Scapula. pelvis & longbones	32.4	41.7	38.8	36.8	41.4	32.8	28.5
Inedible parts of carcass	24.3	9.4	11.2	12.3	14.6	13.4	14.5

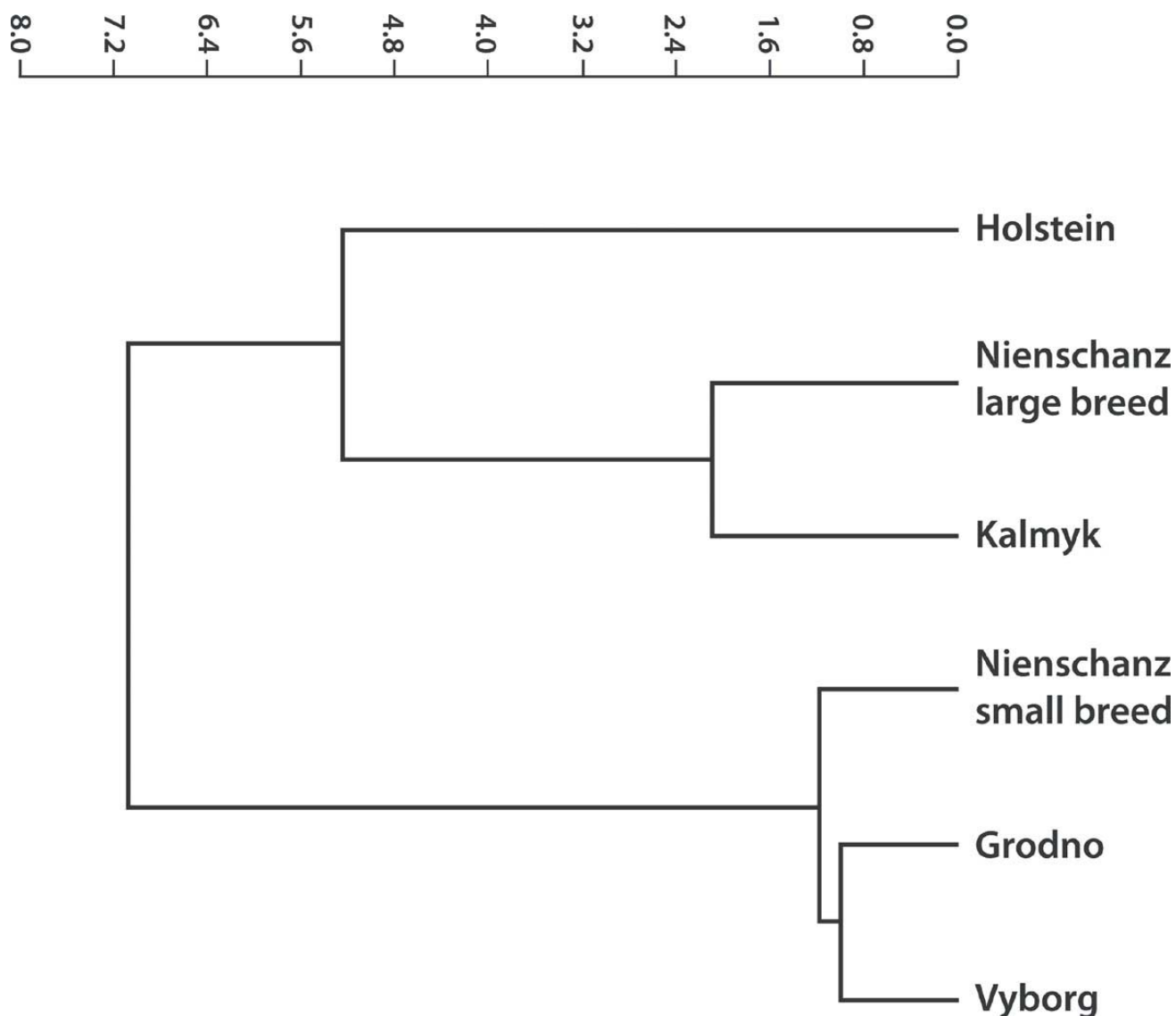


Fig. 32.5. A measure of similarity of proportions of cattle metacarpals from old Vyborg, other archaeological sites, and modern primitive breeds.

The morphological characteristics of the cattle of old Vyborg can be revealed by their metacarpals. The animals are of very small size. Table 32.6 presents the basic measurements from Vyborg, and of the cattle from late medieval Grodno, as well as from the fortress of the Swedish city of Nien, at the mouth of the river Okhta near modern Petersburg, and also of modern primitive Kalmyk cows and Frisian or Holstein cattle.

Kalmyk cattle belong to group of ancient native breeds of North Asiatic origin. They live in very severe conditions, being herded on the steppe all year round (Tsalkin 1960). These conditions are very similar to those in which cattle were kept at late medieval settlements in northern Russia (Kurbatov 2012) and probably some adjacent regions.

Table 32.6. Measurements of cattle metacarpals from Vyborg, from other archaeological sites in northern Russia, and of some modern breeds of medieval origin

	VYBORG (n = 38)		NIENSHANTZ				GRODNO (Tsalkin 1954) (n = 33)		Kalmyk cattle (Tsalkin 1960) (n = 69)		Danish Holstein cattle (Wijngaarden-Bakker and Bergstrom 1988) (n = 67)	
	range	mean	range	mean	range	mean	range	mean	range	mean	range	mean
1	158.0–203.0	170.0	191.5–208.0	201.5	153.0–183.5	167.9	155.0–182.0	168.6	189.0–228.0	207.6	199.0–221.0	210.5
2	39.8–67.0	47.4	57.5–66.0	59.9	42.8–49.0	45.9	42.0–55.0	48.0	51.0–77.0	65.5	69.7–81.0	75.2
3	21.3–27.0	25.2	34.5–37.2	36.2	24.0–28.8	26.4	23.0–31.0	26.1	28.0–48.0	38.2	30.6–45.0	39.0
4	40.0–69.5	48.2	57.0–69.0	65.8	45.0–51.6	47.5	44.0–58.0	48.4	52.0–82.0	66.2	66.7–75.2	70.7

See Table 32.2 for the measurements.

The Holstein or Frisian breed was distributed in the countries around the North Sea, and descend from Asian cattle which reached the Rhine around 300 BC with the nomads who reached there. By the sixteenth and seventeenth centuries the breed was already quite formed, and was widespread in the Baltic region (Houghton 1897).

The cattle from Grodno are typical of those of northern Europe in the fourteenth–seventeenth centuries. Metacarpals from Nienschanz dated to the late sixteenth–early seventeenth centuries reveal that there were two breeds of cattle during this period, based on their size and on the size of some other bones. One breed was large, probably imported and of relatively recent origin. The other breed was small and primitive, and most likely belonged to the local population living in the forest villages around the fortress and city.

Proportional indexes have been calculated for these metacarpals, and this produces an interesting result (Fig. 32.5). The Vyborg cattle are almost identical to their contemporaries from Grodno. They appear very similar to the small-sized animals from the citadel of Nienschanz. The big breed from Nienschanz is however similar to modern Kalmyk cattle, and to a lesser extent to modern Holsteins. The large samples (especially from Vyborg, Grodno and of the modern breeds) make this picture quite reliable. And in contrast to sheep, in this case we can already speak not just about individual examples, but about whole breeds or morphological groups.

It is probable that a breed of cattle was widespread in the Baltic region in the thirteenth–sixteenth centuries. This group covered all the north-western Russian plain, including Vyborg, Novgorod, the Baltic region, the north of Belarus, Poland, and possibly also Germany. They were very small, with an average withers height of 1 m (Tsalkin 1960). The prosperous population of Nien in a later period already cows of the improved breed which were similar to modern steppe Kalmyk cattle, and also somewhat like the present Holstein breed. However, they were similar in size only.

The small size of late medieval cattle in north-western Russia has been considered by Kurbatov (2012). It has been explained by severe conditions, an absence of management skills, and a lack of forage. As a comparison, modern Holstein cattle, the large cattle of Nien, and modern Kalmyk cattle, all reach about 120–130 cm.

The general anatomical composition structure of the cattle remains is presented in Table 32.7. On the whole it is similar to that for caprines. For instance in period 3 we see the same sharp reduction in cranial fragments, and some increase in the meat-bearing elements. However, fragments of longbones, scapulae and pelvis are most numerous in period 4, i.e. at the time when the proportion of caprines decreases. But in period 1 the proportion of inedible parts increases, that of meat-bearing fragments decreases, and that of vertebrae and ribs increases. The situation for caprines was almost identical at this time.

Table 32.7. Anatomical distribution in percentages of the bones of domestic cattle at Vyborg, subdivided by period

<i>Anatomical categories</i>	<i>Periods</i>						
	7	6	5	4	3	2	1
Cranial frags	25.2	39.6	17.7	16.2	9.6	11.4	11.0
Ribs & vertebrae	34.2	31.2	38.9	41.0	39.6	29.4	42.6
Scapula. pelvis & longbones	27.7	20.2	32.7	25.9	32.2	36.6	23.7
Inedible parts of carcass	12.9	8.7	10.7	16.9	18.5	22.6	22.7

The main difference between the anatomical compositions of the cattle and caprine assemblages is that ribs and vertebrae of cows were the most numerous during all periods, more common than fragments of longbones, scapulae and pelvis – but for sheep and goats it was the converse. The average length of fragments of cow ribs is 9–12 cm. It is evident that many fragments were deliberately cut to this size. This was apparently the optimum size placing into a medium-sized cooking vessel. This confirms once again that this is food waste, and indirectly testifies to the fact that meals were cooked individually.

Pig

Pig are not numerous in any period, and their proportion does not vary much, remaining around 10–11%. No measurable element is present in sufficient numbers to produce a large sample. Astragalus (n=6) produced the following measurements: greatest lateral length (GLL) range 36.8–42.4 mm, mean 39.1; distal breadth (Bd) range 20.0–26.7, mean 22.9. The index of the ratio of Bd to GLL is 58.4. The same measurements from Nienschanz (n=4) have a GLL range of 38.6–48.7, with a mean of 43.2; Bd range 22.7–2.0, mean 25.7. The Bd:GLL index at Nienschanz is 59.5. V. I. Tsalkin (1954; 1956) gives the following astragalus lengths from some archaeological contexts: Grodno average length 37.9 mm (range 35.0–43.0, n=16); pigs from cities in ‘the forest belt of ancient Russia’ including Novgorod, Pskov, Moscow and Old Ladoga have averaged length of 38.1 mm (range 32.0–48.0, n=299). Unfortunately, he does not give Bd. It is likely that we are dealing with a morphological group of small-sized domestic pigs which was widespread in the north-west area of the European part of the former USSR. Pigs from Nienschanz are on average a little larger in size, but they hardly differ from the

Vyborg examples on their astragalus proportions.

Other domestic animals

Other domestic animals such as the horse and dog are represented by a few scattered bones. This is to be expected since the investigated bone remains are food waste. Neither horses nor dogs were eaten in fifteenth–seventeenth century Vyborg, and consequently their presence in the faunal assemblage is random. Dogs, however, lived in the city, and probably in large quantities. The marks of their teeth on many bones testify to this. The proportion of bones gnawed by dogs during the fifteenth–sixteenth centuries rises from 5% to 7 % and falls back to 3.7% at the end of seventeenth century. Judging by the size of their bones, the dogs were small. Their size was approximately that of the Karelian malamute.

Wild animals

The complete absence of remains of elk, which must have been rather numerous around Vyborg in the fifteenth–seventeenth centuries, is a mystery. It is possible to refer to this forest dweller only one isolated rib of very large size, the as large as that of a domestic cow. The remains of brown bear, another forest animal undoubtedly numerous at the time, are also very rare. However, a lot of hare bones are found. Thus we can assume that the hunting of large wild animals was hardly practiced, while hares were evidently hunted frequently. It is clear from the bones that they come from hare, not domestic rabbit. In those few cases when it was possible to determine the species, it was always mountain hare (*Lepus timidus*).

Three fragments of bones of a medium-sized seal, most likely ringed seal, are found in period 1. It is possible that seals were used as an occasional food source during this uneasy period of the settlement's existence.

Birds

Bird bones are present in insignificant quantities. Some are unidentified. Some fragments were identified to species by Dr A. V. Panteleev, a scientific researcher at the Zoological Institute of the Russian Academy of Science in Petersburg. The species in a sample of the ornithological remains are presented in Table 32.8.

Bones of domestic hen are most numerous in all periods. However, various wild species are also present. The proportion of wild birds is greatest in period 4 (last quarter of the sixteenth–first half of the seventeenth centuries), and in the last period (end of the seventeenth–beginning of the eighteenth centuries). This is the period, as already mentioned, when the standard of living of the inhabitants of Vyborg (at any rate, of those who occupied the houses situated around the excavation area) had fallen considerably.

Table 32.8. Identified bird bones from Vyborg, by period

<i>Species</i>	7	6	5	4	3	2	1
Whooper swan <i>Cygnus cygnus</i>				1			
Greylag goose <i>Anser anser</i>		1	1	2	1		13
Mallard or wild duck <i>Anas platyrhynchos</i>					1		1
Goldeneye <i>Bucephala clangula</i>	1						
Smew <i>Mergus albellus</i>							1
Capercaillie <i>Tetrao urogallus</i>		1	1	5			3
Hazel grouse <i>Tetrastes bonasia</i>			1	1			5
Woodcock <i>Scolopax rusticola</i>				1			
Eagle owl <i>Bubo bubo</i>				2			
Magpie <i>Pica pica</i>		1					
Domestic hen <i>Gallus gallus</i> <i>var. domesticus</i>		8	7	22	14	7	56
Total	1	11	10	34	16	7	79

Identifications by Dr A. V. Pantleev, Zoological Institute of the Russian Academy of Science.

There is no doubt that these wild species of bird, probably with the exception of the magpie and eagle-owl, were hunted for food, as knife cuts are found on some of their bones as well as on those of domestic hens.

Conclusion

It is evident that the species frequency among the osteological remains from Swedish Vyborg did not change much over almost 300 years. Cow as always the most common, caprines were in second place, and pigs third.

Sheep by the start of the eighteenth century were already similar to modern ones in the region. Probably it was a form directly ancestral to the Romanovskaya breed, which was developed in the

eighteenth century and exists into the present day. The goats are reminiscent of those from late medieval Novgorod and Pskov.

The cattle were similar to those widespread over the whole northern region (in old Grodno, in Vyborg, or in Swedish Nien).

The remains of other species of animals, both wild and domestic, were not very numerous. Bones of horse and dog, common domestic animals, are almost absent. This is explained by the fact that we are dealing primarily with food refuse, and these species were not used as food. There were undoubtedly many horses in the city, used as everywhere else for draft and transport purposes. However, dead animals were probably buried in some special place, and their remains did not get into the normal cultural layers of the settlement. The presence of dogs is shown by their toothmarks on many bones.

Approximately in the middle of the seventeenth century Vyborg survived a decline, and the standard of living of the population fell somewhat. This is shown by the change of diet.

The urban economy of Vyborg changed a little in the last period of its existence under the sovereignty of Sweden, directly before the transition of the region into the Russian empire. Hunting and fishing start to play slightly greater role. Goats are deliberately kept for their fibre. It is possible that during this period there was also a slaughter-house, somewhere near the excavated area. This may have been a place of primary butchery of carcasses, after which they could be sent for sale.

In summary, it is necessary to underline, that all of the above-stated facts apply only to that small part of the city where the excavations were undertaken; although most likely they reflect general trends of change in city life in the sixteenth–seventeenth centuries.

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Dear, oh deer! The adventures of compiling comparative collections: a cervid skeleton allegedly from Egypt's Eastern Desert

Salima Ikram and Louise Bertini

Tony Legge was an extraordinarily generous and perspicacious archaeozoologist. Both authors owe a great deal to him in terms of his knowledge, patience, guidance, and sense of humour. The first author, in particular, is indebted to Tony for forming her ideas of archaeozoology, the potential of animal bones for the better understanding of the past, and as an ideal of collegiality in the field. She had related the following tale to him in brief, and he had urged her to write it up as an example of the complexities of forming comparative collections. Thus, this article is both inspired by and dedicated to Tony.

Recently, a deer-related curiosity in Egypt has come to the attention of the authors. While building up a reference collection of skeletons for the American University in Cairo's Ibrahim Helmy Memorial Bioarchaeology Laboratory, we realised we needed gazelle (*Gazella dorcas dorcas*) and ibex (*Capra ibex nubiana*) skeletons. Both these animals are found in Egypt's Eastern Desert, and Bedouin often come upon dead specimens, or indeed, hunt these animals for their meat, hide, and horns. During a rock art survey in the Eastern Desert a gazelle skeleton was found, thus leaving only the ibex outstanding. A request for such a skeleton was put out to the local Bedouin through the Biology Department Laboratory's Zein el-Abdin. A few false alarms later, after a period of 6 months, Zein phoned in great excitement stating that he had an astonishing type of *taytal* with amazing horns that he had gone to the Eastern Desert to obtain from his contact. We made an appointment and he brought in a large sack containing the skeleton. As we unpacked it we were stunned to find that rather than the skeleton of an ibex, we were unpacking what appeared to be the bones of a red deer (*Cervus elaphus*). The entire skeleton was present, with the head supporting an impressive rack of antlers (Figs 33.1 and 33.2). The animal appeared healthy, with only some carpals, tarsals, and teeth missing. The maxillary M1 had long since disappeared and the bone reabsorbed.

Once we had pointed out the fact that this was not what we had wanted or expected and in no way matched the name or image of the animal we had requested, we examined the bones as we were suspicious about the origins of the skeleton – which was relatively fresh as the bones were still somewhat fatty despite having been prepared. Zein, once he recovered from the fact that we were not pleased with this lavishly horned animal, was adamant that it had come from his Bedouin contact in the Eastern Desert. We explored the other alternatives, but soon established that neither the Cairo Zoo held any such deer – they only had the two types of *Dama* and the Red Nile Lechwe, the only '*ahmer*' (red)

so-called deer in the collection. The zoo was last checked in early January 2014 for their collection of deer, and zoo personnel were asked if in their memory (zoo employees retire at 60 or 62, in keeping with Egyptian law) any red deer had formed part of the collection. Nor did any of the other private zoos, which all specialize in African fauna. Thus, contrary to all logic, it seemed that the Bedouin had found this animal somewhere in the Eastern Desert, defleshed it, and presented it to Zein to complete the preparation of the skeleton.

The measurements of the skeleton (following von den Driesch 1976) are laid out in Tables 33.1–33.4, with comparative measurements of known red deer from Richmond Park, Surrey, United Kingdom, graciously provided by Naomi Sykes and Frazer Bowen, are set out in Tables 33.2–33.4. Additional measurements of red and both types of fallow deer can be found in the Deer Bone Database website (Deer Bone Database 2014). The Cairo deer's measurements fall between those of a female red deer, and a fallow deer. For example, the Bp of the Cairo skeleton's radius (right) is 39.35 mm, while the British red deer is 56.53 mm; European fallow deer measurements from Turkey range from 27.9 mm to 44 mm, far more in keeping with the Cairo deer. The Bp of the Cairo tibia is 58.04 mm, while the tibia in the British group ranges from about 72 mm to 74 mm, and the Turkish European Fallow Deer Bp falls between 49 mm and 62 mm, once again, more in keeping with the Cairo skeleton. Clearly, the Cairo skeleton's size is closer to that of fallow deer; however, the antlers are clearly those of a red deer. If this deer is indeed from somewhere in the Eastern Desert, a limited diet and harsh environment might possibly be responsible for the successful survival of a smaller sized animal, although there are no pathological indicators to suggest nutritional and environmental stress. Alternatively, it might be that the Cairo deer is actually a fallow deer, but that environmental stress is responsible for the lack of palmation.

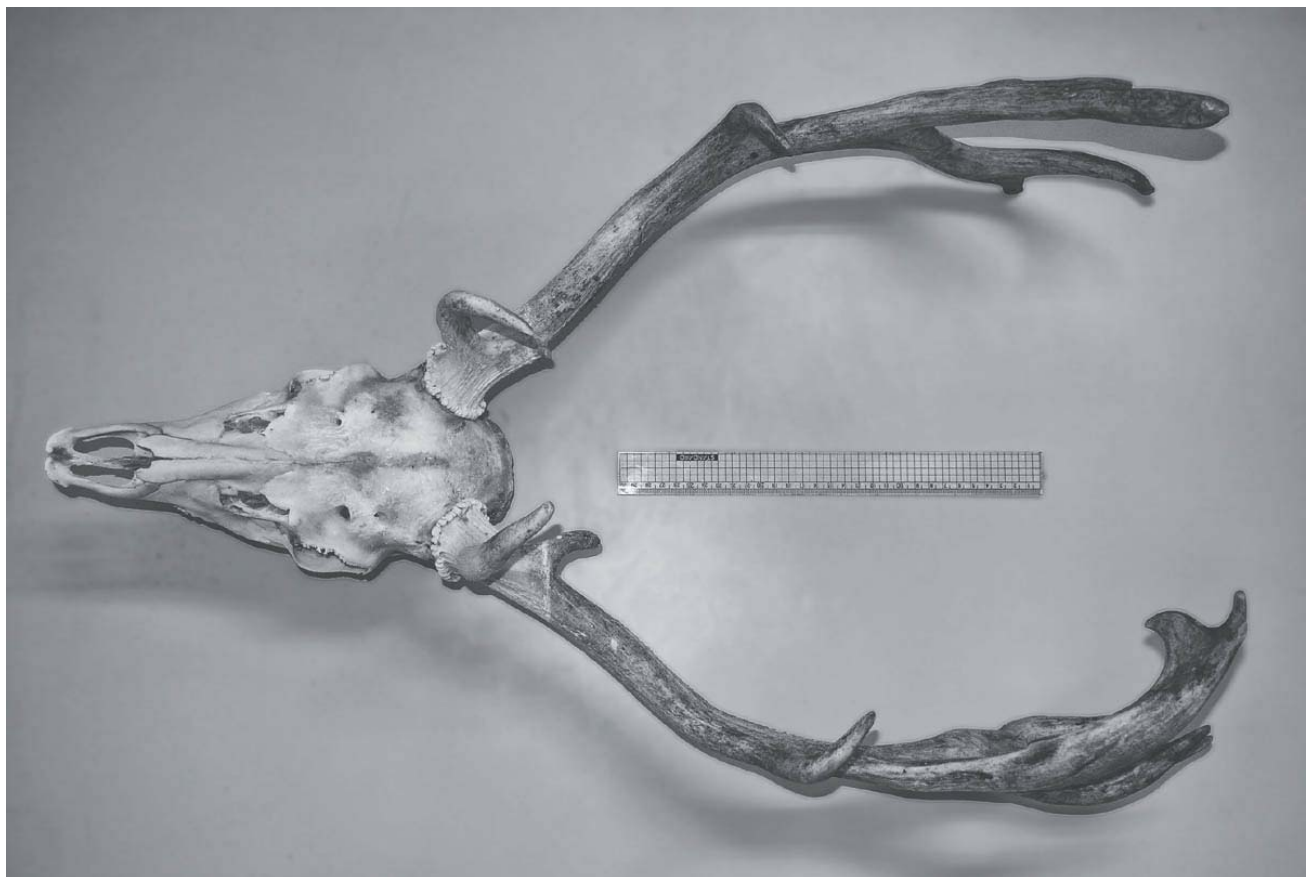


Fig. 33.1. The Cairo deer, anterior view.

The primary question for us is, where did this skeleton come from? No such animals are attested in Egypt now (Osborn and Helmy 1980). However, writers of the eighteenth century, such as Prosper Alpin (1735) and even of the nineteenth century, for example Hartman, writing in 1864, claim that deer were known in Egypt (Darby *et al.* 1977, 238) at those times.

Although cervids do not seem to be indigenous to Egypt (Churcher 1974; Osborn and Helmy 1980) there are as many as 33 attestations of cervids in mainly two-, but also three-dimensional Egyptian art (Kitagawa 2008; Houlihan 1987; Keimer 1934). These images appear intermittently from the earliest periods of Egyptian history (c. 3100 BC) on cosmetic palettes, such as the Hunter's Palette in the British Museum (EA 20790) through the fourth century BC, as depicted in the tomb of Petosiris at Tuna el-Gebel (Lefebvre 1924). Representations of cervids are found most commonly in tomb art, where they feature amongst wild animals being brought as food offerings to the deceased. The name given to them is *hnn* in Egyptian. These animals are not only a source of protein, but also are indicative of the deceased's symbolic and physical control over chaos and untamed nature in an effort to establish the rule of *maat* or order.



Fig. 33.2. *The Cairo deer, lateral view.*

Hnn are also occasionally mentioned in texts, primarily medical ones, although the Annals of King Tuthmose III (1479–1424 BC) lists a deer amongst other animals that were imported from Syria (Sethe 1907, 718 line 89; Davies 1922, 47, n. 2). In medical texts the antlers (hartshorn) are most often mentioned to fumigate men (Berlin Medical Papyrus 69, 70 [Bardinet 1996, 418]), or to rid someone of a fever (Ebers Papyrus 259, Ostraka Louvre 70 [von Deines and Grapow 1959, 331]), as a cure for a headache (Ebers Papyrus 48) (these two being the most common uses of hartshorn in more recent

times), or to remove ‘setet’ (untranslated) from certain places in the summer or winter (Bardinet 1995, 426). Deer liver is supposed to help against snake-bite (P. Brooklyn 47.218.48; 48a; 47.b; 85 [Bardinet 1995, 532–533]), as is the animals’s blood (P. Brooklyn 47.218.48: 91c [Bardinet 1995, 544]).

Hilzheimer (1913) initiated a discussion of the deer species shown in Egyptian art when he noted their presence in the Dynasty V funerary complex of King Sahure (2464–2452 BC). Subsequently, Keimer’s (1934) article on the topic provided an admirable overview of representations of deer in Egyptian art, with images, text, and the animals’ possible existence in Egypt further discussed extensively by Houlihan (1987), while most recently, the osteological and pictorial evidence has been thoroughly analysed by Kitagawa (2008).

The evidence presented in these different publications supports the idea that deer of some sort were known to the Egyptians from at least 3100 BC onward, although they were probably never indigenous to the country, and were brought in intermittently from other areas.

Based on the work of the authors mentioned above, as well as other scholars who have addressed the topic (Butzer 1975; Benedite 1918, Darby *et al.* 1977, 244, fig. 5.17, 262 n. 7; Joleaud 1935), three types of deer have been proposed as possible models for the deer depicted in Egyptian art: European fallow deer (*Dama dama*), Mesopotamian fallow deer (*Dama dama mesopotamica*), or Barbary red deer (*Cervus elaphus barbarus*); it is also, of course, possible that it was not a single type of cervid depicted in all 33 representations, but different ones, depending on the depiction and time period.

Table 33.1. Skull measurements of the Cairo skeleton

Skull measurement	(mm)
1	307.12
2	280.58
3	254.25
4	172.99
5	81.26
6	33.63
7	220.62
9	153.59
10	153.6
11	134.95
12	235.41
13	280.54
14	204.64
15	98.53
16	153.62
17	153.6
18	126.93
19	71.84
20	75.75
21	46.91
22	28.84
23	47.75
24	45.48
25	100.73
26	52.74

27	89.84
28	23.56
31	109.98
32	130.01
33	103.12
34	132.12
35	23.72
36	34.19
37	82.43
38	66.76
41	31.25

Measurements follow von den Driesch 1976

The European fallow deer was reported to exist in Libya, Tunisia, and an area near the Algerian/Tunisian border until late in the last century (Houlihan 1987, 241), possibly introduced by the Romans and maintained there (Joleaud 1935, 2, 8, 17). Other options are that fallow deer were possibly introduced into Egypt during the sixteenth century AD or before (Joleaud 1935, 17), and continued to live in the wild, particularly in the area of the Wadi Natrun, until the nineteenth century, as evidenced by the dressed skin of one such animal that Bernadino Drovetti (4 January 1776–1852), the French consul general at Alexandria, presented to the Duc d'Angoulême (Joleaud 1935, 17–18; Darby *et al.* 1977, 238–239). It is also possible that the European type might have come from the area that is now Greece (Kitagawa 2008: 222), as well as parts of Anatolia, and arrived in Egypt as gifts or traded items.

Hilzheimer espoused the argument that Persian fallow deer had migrated to Egypt from Western Asia during the Pleistocene (1913, 168–172), using the Suez Isthmus (Churcher 1974, 279–280), and thus might have become an indigenous Egyptian species – however, the marked paucity of these animals in the artistic, textual, and archaeozoological evidence argues against this. It is more probable that these animals were imports as booty, tribute or trade items from the Near East where their remains are commonly found in the Levant (Boessneck and von den Driesch 1979; 1989; Kitagawa 2008), rather than a species found in Egypt.

The Barbary red deer (*Cervus elaphus barbarus*) is a species that is still found in Tunisia (Houlihan 1987, 241, 243). However, its origins remain obscure, and no zooarchaeological remains are attested. However, if a few examples of red deer did exist in Egypt, they could also have arrived from Asia Minor where they are still found. They could have been gifts or traded objects – indeed, the schematic depiction of antlers found in Egyptian art have much in common with the Hittite representations of deer (for example, see illustrations in Collins 2003).

The majority of osteological remains of deer in Egypt come from the eastern delta sites of Pi-Ramesses/Qantir. For the most part, it could not be determined whether the bones came from European (*Dama dama*) or Mesopotamian fallow deer (*Dama mesopotamica*) (Kitagawa 2008: 219). However, it is clear that they do belong to one or the other types of fallow deer, but not to red deer (*Cervus elaphus*).

None of the Egyptian representations of deer are clear enough for a secure taxonomic identification, with all of them showing relatively schematic antlers, which are rarely well defined enough to identify as palmate or merely as branched. Thus, for the moment, the identity of the types of deer depicted by the ancient Egyptians is still a matter of debate, although it is most probable that they were some species of *Dama*. However, none of this explains the presence of our skeleton that is purportedly from the Eastern Desert. It should be noted that one of the authors actually purchased a

piece of antler (which looks very much like that of a *C. elaphus*) from one of the shops of folk healers (*souk el attarin*) in Cairo. The healer recommended that it be ground up and drunk, in order to chase away demons that might particularly manifest their presence through headaches! In terms of its origins, the healer claimed that it was rare, and that it came from the southern part of the Eastern Desert – maybe the Wadi Allaqi.

Table 33.2. Mandible measurements (mm) of the Cairo skeleton with Richmond Park (RP) comparatives

Measure-ment	Cairo specimen		Richmond Park			
	Right	Left	Female		Male	
			Right	Left	Right	Left
1	213.87	214.54	297	297	288	288
2	229.2	230.12	–	–	–	–
3	57.81	56.49	–	–	–	–
4	149.63	151.06	–	–	–	–
5	141.83	139.42	–	–	–	–
6	175.17	175.53	–	–	–	–
7	83.1	83.07	–	–	–	–
8	51.56	51.85	80.69	78.34	70.26	69.37
9	31.54	31.22	48.59	45.59	43.53	48.42
11	67.65	68.59	85.05	85.16	87.02	87.2
12	72.06	74.11	–	–	–	–
13	76.92	75.25	106.99	106.44	102.21	100.33
14	106.54	108.51	153	154	139	138
15a	28.67	29.52	–	–	–	–
15b	26.85	24.87	29.19	29.02	35.76	33.74
15c	24.69	23.71	25.74	26.83	33.39	31.96
m3B	11.81	11.61	–	–	–	–
mcL	27.25	26.06	–	–	–	–

Measurements follow von den Driesch 1976

A possible explanation – admittedly a bit far-fetched – is that a small population of these animals *does* exist in Egypt, a vestige of a gift to an Egyptian monarch. One should remember that Alpin and Hartman (Darby *et al.* 1977, 238) both stated that they saw stags in Egypt. Certainly there are paintings dating to 1512 showing a Venetian embassy at the Egyptian court where an antlered animal was let loose amongst the dignitaries (Darby *et al.* 1977, 238), with an eye-witness account by the traveler, Pierre Belons du Mans (Sauneron 1970, 119b), who describes the liberation of such an animal in court in 1547. Maybe a small pocket in the Wadi Allaqi contains a tiny population of renegade *C. elaphus* or *dama* – though rangers from the reserve in that area deny all knowledge of these animals.

Thus, the authors are no closer to finding out where this animal might have come from, and are still pursuing various avenues of investigation (DNA in particular) to try to determine how a (relatively fresh) skeleton of a cervid came to be in their comparative collection in Cairo – the type of puzzle that would (and did) have amused and entertained Tony.

Table 33.3. Atlas and axis measurements with Richmond Park (RP) comparatives.

<i>Bone</i>	<i>Measurement (mm)</i>	<i>RP: female</i>	<i>RP: male</i>
Atlas	GB	100.58	100 —
Atlas	GLF	66.52	80.35 —
Atlas	GL	81.98	87 —
Atlas	BFcd	57.39	67.33 76.42
Axis	BCcr	55.8	70.98 —
Axis	SBv	39.34	— —
Axis	LCDe	85.18	102.85 110
Axis	Bpacd	48.83	54.86 50.69

Measurements follow von den Driesch 1976

Table 33.4. Long bone measurements (mm) of the Cairo specimen with Richmond Park (RP) comparatives

<i>Bone</i>	<i>Measurement</i>	<i>Cairo specimen</i>		<i>Richmond Park</i>			
		<i>Right</i>	<i>Left</i>	<i>RP: female</i>		<i>RP: male</i>	
				<i>Right</i>	<i>Left</i>	<i>Right</i>	<i>Left</i>
Scapula	GIP	43.92	44.44	58.24	58.95	55.65	55.24
Scapula	BG	31.93	32.4	39.97	41.59	40.45	40.45
Scapula	LG	33.66	34.73	46.76	46.67	44.01	43.17
Scapula	SLC	26.07	26.3	34.9	34.75	34.62	35.15
Scapula	HS	206.55	205.3	240	240	264	266
Scapula	DHA	199.52	107.77	—	—	—	—
Scapula	Ld	134.61	133.34	136.55	137.03	156	157
Pelvis	GI	260.25	261.62	290	290	326	327
Pelvis	SB	27.06	28.12	—	—	—	—
Pelvis	Lfo	53.55	53.44	—	—	—	—
Pelvis	LS	89.45	89.45	—	104.44	—	—
Pelvis	LA	43.07	43.43	49.89	50.77	53.75	53.7
Humerus	GI	192.46	193.45	243	242	268	272
Humerus	Sd	20.78	20.87	25.34	25.37	—	—
Humerus	Bd	40.79	41.77	55.91	57.92	56.32	56.34
Humerus	Bt	33.99	33.58	49.11	51.35	58.85	58.39
Humerus	Bp	51.94	51.35	68.03	69.07	73.24	73.9
Ulna	BPC	22.29	20.73	—	—	—	—
Ulna	LO	56.16	56.8	69.4	71.58	63.6	62.68
Ulna	DPA	36.66	37.79	—	—	—	—
Ulna	SDO	32.1	32.68	—	—	—	—
Radius	Bp	39.35	38.91	53.21	54.43	56.53	56.19
Radius	Bfp	33.69	34.26	47.52	48.83	50.36	50.62
Radius	Bd	37.83	38.21	48.93	49.17	53.37	52.63
Radius	GI	194.43	193.86	265	263	292	292
Radius	SD	23.64	23.61	26.74	26.24	30.72	30.07
Metacarpal	Bp	31.36	31.86	—	—	—	—
Metacarpal	GI	187.32	186.2	—	—	—	—
Metacarpal	SD	18.94	18.4	—	—	—	—
Metacarpal	Bd	29.23	29.41	—	—	—	—
Femur	GI	232.48	232.6	292	293	323	323
Femur	GLC	230.9	230.54	274	273	313	312
Femur	Bp	62.28	61.59	75.36	75.41	86.7	88.75
Femur	SD	21.83	22.27	25.8	25.9	27.52	27.76
Femur	Bd	49.05	49.28	65.13	66.33	70.33	70.86
Tibia	Bp	58.04	57.83	71.89	70.63	74.26	74.18
Tibia	Sd	22.47	22.9	25.55	25.71	27.74	27.63
Tibia	Bd	38.24	37.1	43.06	42.72	46.41	47.8
Tibia	GL	269.95	268.54	327	326	373	372
Tibia	LI	265.75	265.12	—	—	—	—

Bone	Measure- ment	Cairo specimen		Richmond Park			
		Right	Left	RP: female		RP: male	
				Right	Left	Right	Left
Metatarsal	Bp	31.14	30.25	–	–	–	–
Metatarsal	Gl	209.72	209.45	–	–	–	–
Metatarsal	SD	21.78	20.83	–	–	–	–
Metatarsal	Bd	30.7	30.43	–	–	–	–
Patella	Gl	38.11	39.27	53.14	–	–	53.35
Patella	GB	31.91	33.36	43.85	–	–	46.72
Calcaneous	Gl	86.34	85.77	107.89	107.17	116.22	116.6
Calcaneous	GB	23.77	23.95	31	31	35	35
Astragalus	DM	20.69	21.82	29.35	29.47	30.51	30.14
Astragalus	GII	37.48	37.73	48.52	48.2	50.61	49.78
Astragalus	GLM	34.98	35.26	45.58	45.61	55.12	55.55
Astragalus	Bd	24.36	24.99	32.64	32	35.03	34.53
Astragalus	DI	22.63	22.72	26.77	26.52	29.17	30.48
PH1	SD	12	12.68	19.11	–	–	–
PH1	Bd	13.37	13.6	14.61	–	–	–
PH1	GL	42.45	42.83	17.85	–	–	–
PH1	Glpe	40.71	40.66	–	–	–	–
PH2	Bp	14.73	15.07	19.77	–	–	–
PH2	SD	11.11	11.54	14.35	–	–	–
PH2	Bd	12.13	12.15	15.87	–	–	–
PH2	GL	30.48	29.09	37.73	–	–	–
PH2	Glpe	27.89	27.52	–	–	–	–
PH3	Ld	34.77	35.39	39	–	–	–
PH3	DLS	40.51	39.27	42.49	–	–	–
PH3	MBS	11.45	10.61	–	–	–	–

Measurements follow von den Dreisch 1976

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